DEC 26 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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See Advertisement, page 98. 1111

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GAS AND OIL ENGINES.
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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
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See half-page Advertisement, page 68, Nov. 23.

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NOTICE.

Mr. A. J. Rayment,

HEAD OF THE TECHNOLOGICAL BOOKS DEPARTMENT at Messrs. Sir Isaac Pitman and Sons, Ltd., is severing his connection with them at the end of the year.
Pending other arrangements, any communications of a personal character may be sent to him c/o THEODORE STEVENS, Esq., M.Inst.C.E., M.I.E.E., 50, Lincoln's Inn Fields, W.C.2. C 415

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Candidates must have reached the age of 17, but not the age of 19, on 1st March in the year of examination, be domiciled in the United Kingdom, and undertake to pursue a three years' Course in Engineering with a view to following it as a Profession.
Papers, which will cover two days' examination, will be set in the following four subjects:—
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MATHEMATICS
MECHANICS
GENERAL PHYSICS.
The Examination for the 1924 Scholarships will be held on 25th and 26th February, and all Application Forms must reach the Committee not later than 21st January, 1924.
The Scholarship Awards will be officially published on 15th May, 1924.
Full particulars and official Application Forms may be obtained from
THE SECRETARY, Scholarships' Committee,
Messrs. NORTON and GREGORY, Ltd.,
1 and 2, Castle Lane,
Westminster, London, S.W.1 C 365

Correspondence Courses for

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TO STEEL BRIDGE ENGINEERING CONTRACTORS.

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Designs and Tenders for the

SUPPLY and DELIVERY and ERECTION (optional) of a number of STEEL GIRDER ROAD BRIDGES on prepared abutments.
Full particulars and conditions, together with copies of site and abutment drawings, may be obtained from the Office of the undersigned on deposit of the sum of £2 2s., which will be returned on receipt of a *bona fide* Design and Tender.
The County Council do not bind themselves to accept the lowest or any Tender.
Sealed Designs and Tenders, duly endorsed, to be delivered to the undersigned as soon as possible but, in any case, not later than the 31st December, 1923.

ALBERT E. BROOKES, M.I.C.E.,
County Engineer and Surveyor.
County Surveyor's Office,
Shire Hall, Durham
4th December, 1923 C 340

THE MINISTRY OF PUBLIC WORKS, EGYPT, are calling for

Tenders for the Supply and

ERECTION of a PUMPING PLANT to replace an existing steam plant at Qassassin. The contract will include the dismantling and removal of the existing plant. Firms quoting must send their Tenders direct to Egypt, where they are due 5th February, 1924.
Forms and Specifications, price 10/-, can be obtained at the Office of THE INSPECTING ENGINEER, Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, S.W.1. C 360

CITY OF LIVERPOOL.

NEW STEAM HOPPER BARGE.

The Corporation of Liverpool Require A NEW STEAM HOPPER BARGE suitable for House Refuse, of approximately 1000 tons capacity, and are prepared to receive

Tenders from Shipbuilders

and Engineers.
Copies of Specification, General Conditions, and Form of Tender will be forwarded upon receipt of application in writing to:—
The City Engineer,
Municipal Buildings,
Dale Street, Liverpool.
Sealed Tenders addressed to "The Town Clerk, Municipal Buildings, Liverpool," and endorsed "Tender for New Steam Hopper Barge," must be forwarded through the post so as to be received NOT LATER THAN TWELVE O'CLOCK NOON, ON TUESDAY, THE 22nd JANUARY, 1924.
WALTER MOON,
Town Clerk.
11th December, 1923. C 366

50-TON OVERHEAD TRAVELLING CRANE (ELECTRICALLY DRIVEN).

Tenders Invited for One 50-

Ton OVERHEAD TRAVELLING CRANE, for Engine Room
Tender Form and Specification can be obtained from the Borough Electrical Engineer, St. Peter's Chambers, Stoke-on-Trent, on receipt of a deposit of £2 (returnable on *bona fide* Tender).
Tenders to the Undersigned by morning of Wednesday, 16th January, 1924.
H. B. SHARPLEY,
Town Clerk.
Town Hall,
Stoke-on-Trent.
10th December, 1923. C 381

COUNTY BOROUGH OF SUNDERLAND.

ELECTRICITY DEPARTMENT.

The Corporation of Sunderland invite

Tenders for the Supply and

INSTALLATION of the following PLANT at their Hylton Road Electricity Works:—
SECTION A. One 10,000 Kilowatt Alternator Turbine and Condensing Plant.
SECTION B. Two Straight Tube Water Tube Boilers, each of 50,000 lbs. evaporative capacity per hour.
SECTION C. Natural draught Wooden Cooling Towers and Concrete Foundations.
Copies of the Specification and Form of Tender for each Section separately may be obtained from the General Manager, Electricity Offices, Dunning Street, Sunderland, upon payment of a deposit of Three Guineas for each Section in duplicate. The deposit will be returned only after a *bona fide* Tender has been received and adjudicated upon, and provided the same has not been withdrawn.
Sealed Tenders, endorsed on cover "Tender for Electricity Works, Section A, B or C," (as the case may be), are to be addressed to the Chairman of the Electricity Committee and delivered at the office of the undersigned, Town Hall, Sunderland, not later than the first post on Monday, the 21st January next.
The Corporation do not bind themselves to accept the lowest or any Tender.
H. CRAVEN,
Town Clerk.
Town Hall,
Sunderland.
10th December, 1923. C 383

BOROUGH OF PORTSMOUTH.

WIDENING OF THE CAMBER.

REINFORCED CONCRETE QUAY, ETC.

The Portsmouth Town Council invite

Tenders for the Construction

and MAINTENANCE in thorough repair for twelve calender months from the Completion thereof, of the following WORKS, that is to say:—
The Widening of Portsmouth Camber, near the end of East Street, Portsmouth, by the removal of the projecting quay-wall there, and the Construction of a reinforced concrete Quay-Wall and other works in connection with making good after the removal of the Camber Bridge, which is now being taken down.
Copies of the Drawings and Specification under which Tenders are invited can be obtained on application (accompanied by the sum of £3, which will be refunded on the return of the documents within seven days, or on the receipt of a *bona fide* Tender accompanied by the documents required) to Mr. ARTHUR W. WARD, The Borough Engineer, Town Hall, Portsmouth, from whom any further particulars can be obtained.
The work will have to be carried out under the requirements of the Government Unemployment Grants Committee and the Trade Union Rules in force in the Borough.
Tenders must be accompanied by details showing how it is proposed to dispose the steel specified for the reinforced concrete, and those tendering may, if they desire, submit their own design for the reinforced concrete work, but no design will be considered unless accompanied by a firm Tender.
Tenders, marked "Tender for Widening Portsmouth Camber," are to be sent in on the form supplied, accompanied by the Drawings, etc., issued by the Corporation, together with drawings, quantities, etc., prepared by the person tendering, as required in the Specification, and must reach the undersigned not later than Ten a.m., on Thursday, the 10th day of January, 1924.
The Council do not bind themselves to accept the lowest or any Tender.
F. J. SPARKS,
Town Clerk.
The Town Hall,
Portsmouth.
10th December, 1923. C 397

The Director-General,

INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, REQUIRES:
1. STEEL TYRES for Railway Carriages and Wagons.
2. HYDRAULIC PLANT, Pumps, three-throw, horizontal, motor-driven, Accumulator, Spring Buckle Press, Spring Scragging Press and Forging Press, four column type. Urgently required.
Tenders due on the 28th December, 1923, for No. 1, and on the 4th January, 1924, for No. 2.
Tender Forms obtainable from above. C 384

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for:—

ONE MOTOR DRIVEN WHEEL LATHE.
Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 7th December, 1923.
A fee of 10/- will be charged for the Specification, which is NOT returnable.
Tenders must be submitted not later than NOON on Thursday, 20th December, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
BY ORDER OF THE BOARD.
R. C. VOLKERS,
Secretary. C 368

GAINSBOROUGH URBAN DISTRICT COUNCIL.

WATERWORKS.

Engine and Pumping Plant for Borehole.

The Council invite

Tenders for the Above Engine

and PUMPS for raising water for the Town's supply from Artesian Borehole.
Plan of the Engine House and site, section of Borehole with Specification, Form of Tender and general particulars will be supplied upon application to S. W. PARKER, Waterworks Engineer, Council Offices, Gainsborough.
Tenders to be enclosed in a sealed envelope endorsed "Tender for Waterworks Pumping Plant" to be delivered or forwarded to the Clerk to the Council, Council Offices, 6, Lord Street, Gainsborough, on or before Monday, the Eleventh day of February, Nineteen hundred and twenty-four.
A deposit of Two Guineas must accompany application for "Form of Tender," plan, specification, etc., and the deposit will be returned upon receipt of a *bona fide* Tender.
The Council do not bind themselves to accept the lowest or any Tender.
Signed,
H. P. MORGAN,
Clerk to the Council,
Council Offices,
Gainsborough.
4th December, 1923. C 333

APPOINTMENTS OPEN.

UNIVERSITY OF BIRMINGHAM.

FACULTY OF SCIENCE.

PROFESSORSHIP OF CIVIL ENGINEERING.

The Council of the University invites

Applications for the Chair

of CIVIL ENGINEERING.
The stipend will be £1000 a year.
The Professor will be allowed to take Higher Consultative work, to keep in touch with Civil Engineering practice, provided that it does not interfere with his University duties.
Applications, accompanied by fifty copies of testimonials, should be received by the Secretary not later than February 4th, 1924.
The successful candidate will be expected to begin his duties on October 1st, 1924.
Further particulars may be obtained from
GEO. H. MORLEY,
Secretary. C 389

The Stanton Ironworks Com-

PANY, LIMITED, near Nottingham, REQUIRE the SERVICES of a FOUNDRY WORKS MANAGER.—Apply, in writing, enclosing photograph, to the FOUNDRY GENERAL MANAGER. C 304

Assistant General Manager

REQUIRED by Constructional Engineering firm established in India. Must be thoroughly competent Engineer, having wide experience of Bridge, Jetty and Steel Frame Building Construction. Must also have commercial experience and ability to negotiate contracts. Public School or University man preferred. Age 34-42. Salary about Rs. 3000 per month and opportunity of participating in profits.—Address, giving fullest particulars, to C 379, Offices of ENGINEERING.

THE SOUTH INDIAN RAILWAY COMPANY, LTD.

An Assistant Electrical

SUPERINTENDENT is REQUIRED for service in India.
The salary of the appointment which, in the first instance, will be for three years, commences on date of embarkation for India, and will be according to qualifications. The passage to India will be paid by the Company.
Candidates, who should be between the ages of 24 and 33 years, should have received a good general and technical education, followed by a training in large Electrical Manufacturing works, and have had experience as Resident or Shift Engineer in a Power House Supply, and be well acquainted with A.C. High Tension and D.C. three wires systems. A knowledge of electrical driving of workshops and of train lighting is desirable.
Forms, upon which applications must be made, may be obtained on written request to Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, London, S.W.1, the Consulting Engineers to the Company.
W. B. REYNOLDS,
for Managing Director.
Company's Offices,
91, Petty France,
Westminster, S.W.1.
8th December, 1923. C 377

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for Engineering Works near Leeds, must be energetic and have initiative and be able to take charge of correspondence and control staff. Age 30-40. Replies stating age, experience and salary required.—Address, C 359, Offices of ENGINEERING.

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GINEER for Railway Survey REQUIRED by the NIGERIAN GOVERNMENT for a Tour of 12 to 18 months' service. Salary £540, rising to £720 by annual increments of £30 and thence to £820 by annual increments of £40. Outfit allowance of £60 on first appointment. Free first-class passages and camp equipment. Liberal leave on full salary. Candidates not over 40 years of age, must be fully qualified Engineers with experience in Railway Location.—Apply, at once, in writing, stating age, and giving brief details of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W., quoting at the top of application, M/12475. C 387

Engineer Wanted by a Large

Firm of Engineers in the Midlands to take control of the engineering side under the Managing Director. Applications only desired from those having the highest qualifications and experience in the design and manufacture of heavy oil and gas engines. State age, experience and salary required. Applications will be treated as strictly confidential. —Address, C 386, Offices of ENGINEERING.

Wanted, an Experienced

Colliery MECHANICAL ENGINEER, as Assistant to Chief Engineer of group of Collieries in Co. Durham.
University Degree a recommendation. Must have experience of modern methods of winding and sinking, electrical knowledge important. Salary at rate of £350 per annum.
The appointment may not be permanent. Age, qualifications, with copies of testimonials.
Address, C 396, Offices of ENGINEERING.

Assistant Engineer Wanted

with good practical knowledge of mechanical and electrical work. Experience in drawing office and outside erection work desirable. State age, experience and salary required.—Address, C 393, Offices of ENGINEERING.

Wanted, a Capable Young

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THE SUORVA LAKES DAMS, LAPLAND.

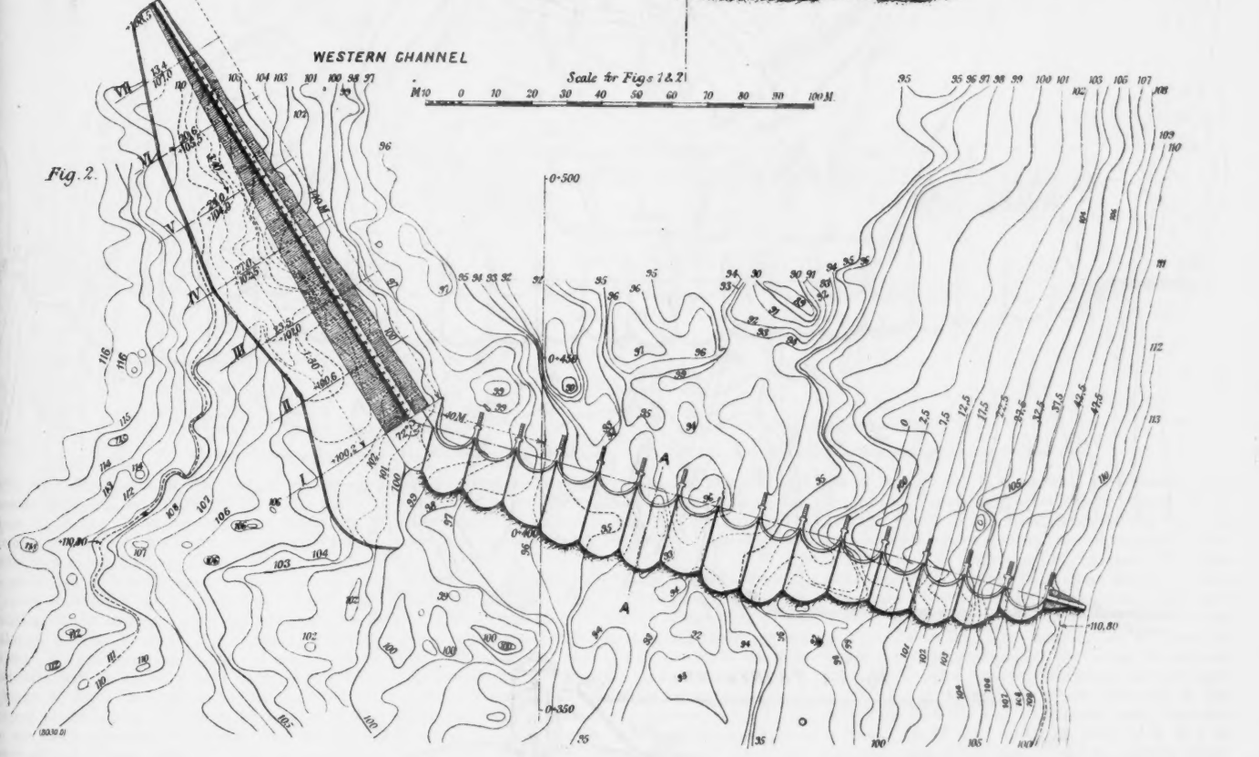
THE Swedish Parliament some years ago voted the necessary funds for a project for regulating the lakes out of which flows the Great Lule River in Lapland. The principal direction which the scheme took was the control of the so-called Suorva Lakes, and this is now being rapidly advanced. Preparatory work in the way of arranging transport, and providing workmen's dwellings was begun in 1919.

The control of the lakes in question is requisite in order to take full advantage of the water supplies available of about 90 cub. m. to 100 cub. m. per second. This, with a total head of about 150 m., would make possible an increase of power generated at Porjus and Harspranget of some 150,000 turbine horse-power, or for the whole of the Great Lule Water to the sea, for which an aggregate head of 360 m. is available, increased possibilities to the extent of 450,000 turbine horse-power. In considering the conditions, a maximum flow of 920 cub. m. per second has been taken as the greatest yield for a catchment area of 200 sq. km.

At the site selected for the control works the outflow from this system of lakes is by way of two

Fig. 1.

Fig. 2.



of the area, principally in connection with the existing hydro-electric generating stations at Porjus and Harspranget. The object is to store water in a period of ample supply, to supplement the amount available from the run-off during parts of the year when the normal flow is decreased. Of the system of lakes which together are known as the Suorva Lakes, several, having an aggregate area at normal water level of 196·9 sq. km. (76 sq. miles), will be affected by the present scheme which includes the construction of two dams. These are to be built so that they can be subsequently raised, when another lake of some 20 sq. km. area would also be affected. The difference in level between the various lakes is actually very small. The following table, summarising the results of local observations, illustrates the great differences which occur in the volume of water and the levels recorded, and indicate the advantages to be derived from regulation:—

	Water Level. m.	Volume of Water. Cub. m. per Sec.
Extraordinarily low water level	96·52	9
Ordinary low water level (average for six years) ...	96·61	13
Ordinary high water level (average for five years)...	100·38	690
Highest recorded water level	100·70	892

It is proposed to raise the water level ultimately to a level of 109 m. or 110 m., which it is calculated will result in an additional supply being regularly

Fig. 3. SECTION A–A.

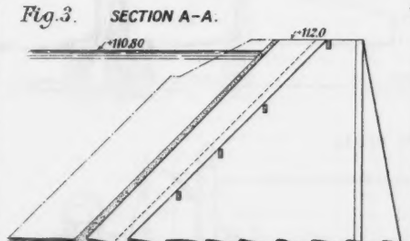
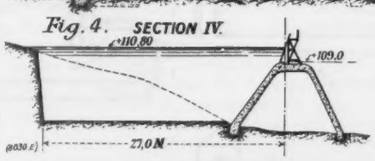


Fig. 4. SECTION IV.



channels. Drawings of the dams, are given on this and the following pages, while on page 746 are reproduced some views taken during construction. The contours, &c., are given in Figs. 2 to 6, on the present page and page 732. The type of dam adopted will be more fully described later on. The illustrations, Figs. 3 and 4 show the structure carried up to its final height, for a water level of 110 m. This full height, however, is not to be built at present, a temporary height to bring the water level to 104·5 m. having been decided upon as satisfying present needs. This necessarily modified some of the arrangements, as the maximum discharge had to be provided for although the location of the spillway on one wing of the western dam (Fig. 2) rendered the full discharge at this point unavailable through the reduced height. To supplement the small part which could be utilised, temporary arrangements had to be adopted at other parts of the dam, to cope with emergencies. These are indicated in Figs. 10 to 13, page 733, which show the dam carried up far enough for the 104·5 m. level only. In the Eastern Channel, which is completely blocked by a dam, a similar temporary height has been adopted. In this channel no spillway is provided, and the arrangements for regulating the discharge of the impounded water are such as will serve for the scheme when the dam is carried to the full height. The main difference therefore in plan of the temporary structure, from that shown in Fig. 6, lies in reduced length at either end.

As a result of careful preliminary investigations it was decided that the most economical type to adopt for the Suorva dams would be a multiple-arch design, the structure being built of reinforced concrete. In this form of dam the water pressure is taken by a number of arched surfaces of comparatively small span and supported by buttresses extending down stream. In the case of dams of this type built in other countries, the arches have been spanned by horizontal stays, and the buttress pillars have been reinforced so that the tendency to spread is wholly resisted by these stays. This has been done in order to make the arches independent, so that failure at one point shall not involve the destruction of the whole.

In America, where dams of this type have been constructed under climatic conditions similar to those existing at Suorva, possible ice pressure was not considered, neither have arrangements been made for avoiding extremely low temperatures in the structure, by earth filling. At Suorva, however, the structure has been designed to allow of filling being placed on the up-stream face of the dams,

THE SUORVA LAKES DAMS, LAPLAND.

Fig. 5.

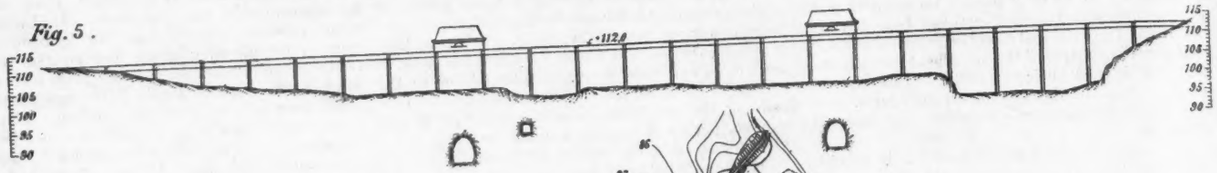


Fig. 6. EASTERN CHANNEL

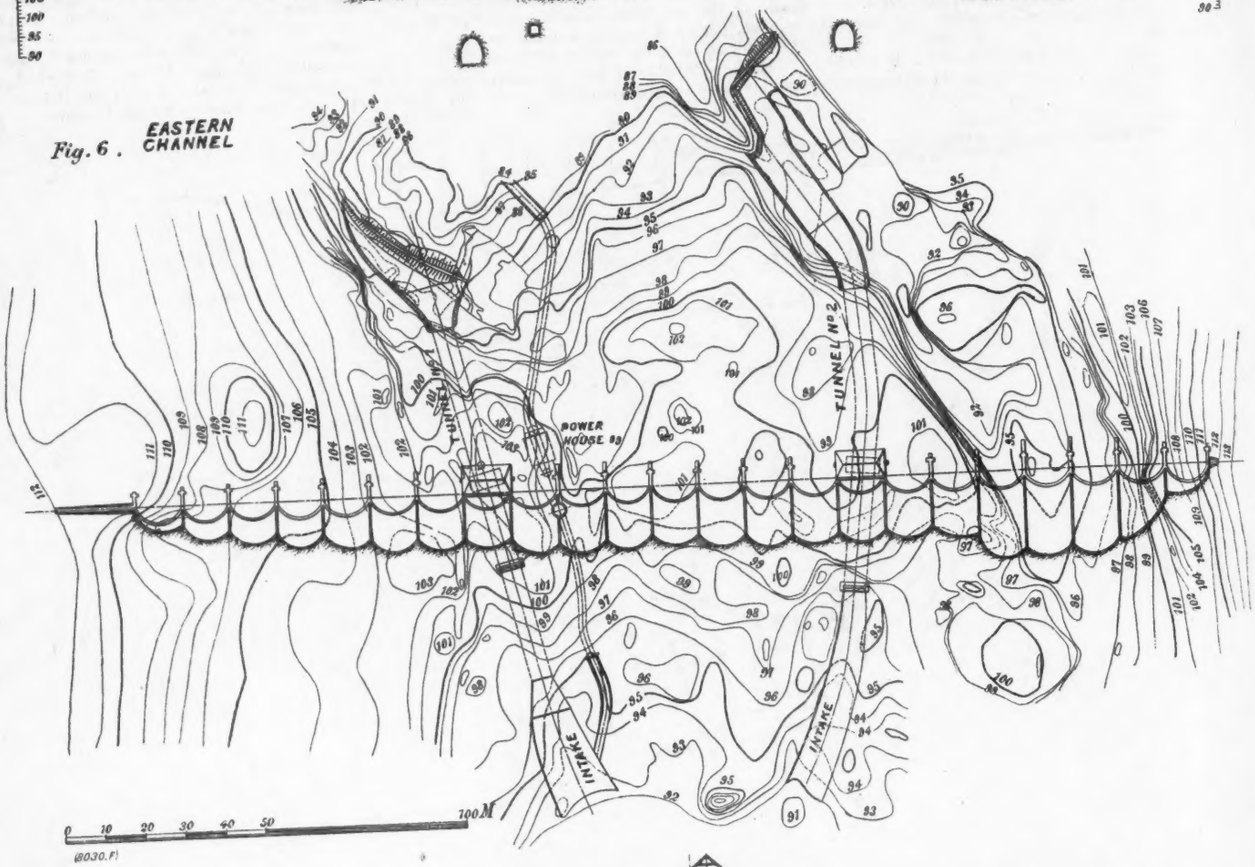


Fig. 7. TUNNEL N° 1

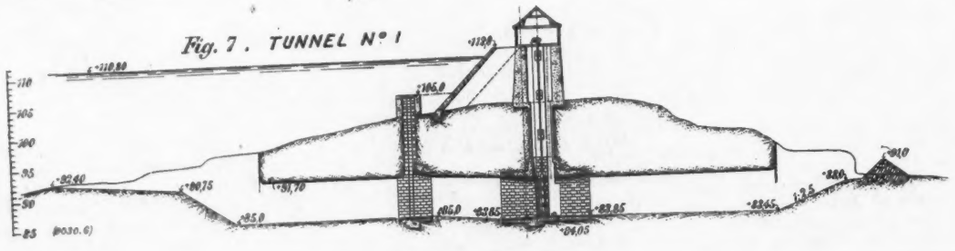


Fig. 8. TUNNEL FOR POWER HOUSE

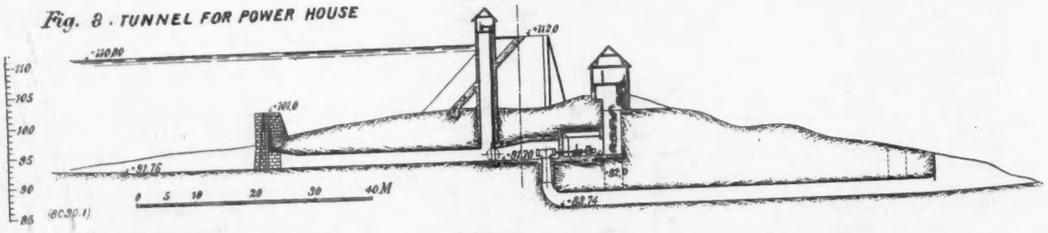
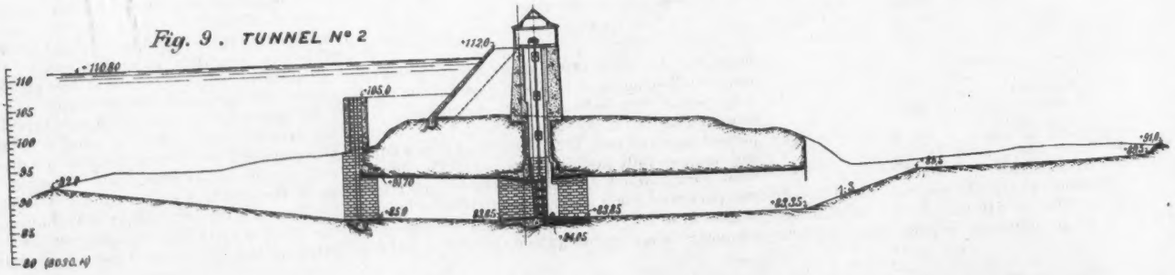
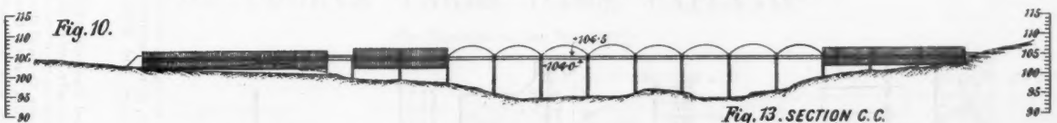
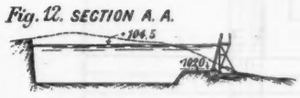


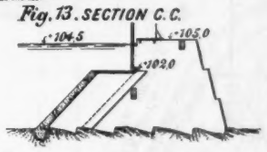
Fig. 9. TUNNEL N° 2

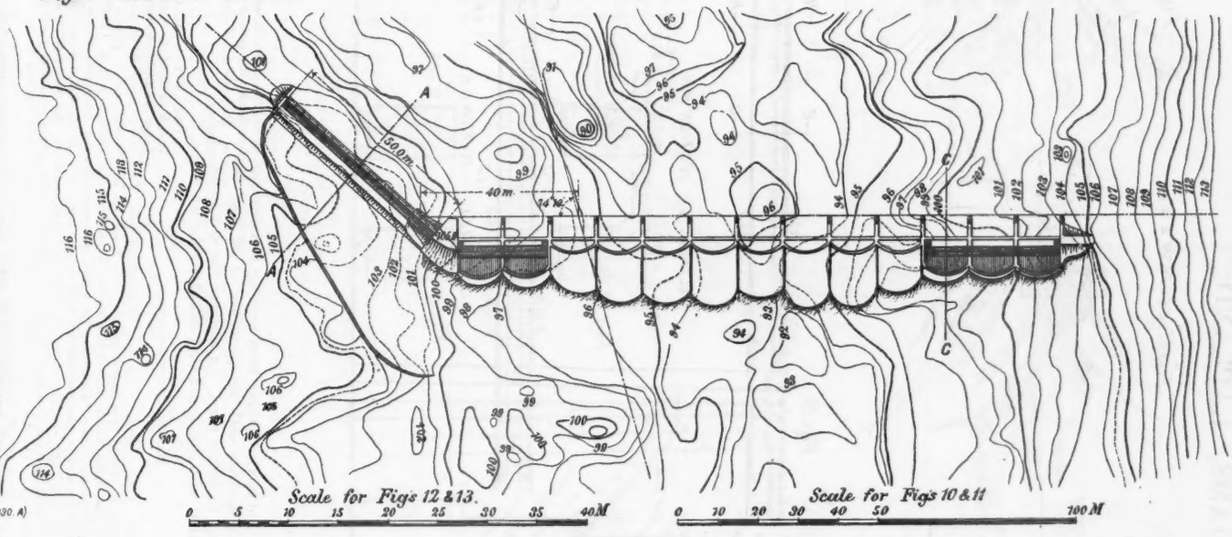


THE SUORVA LAKES DAMS, LAPLAND.









partly with the object of distributing any possible pressure from ice, and partly with a view to providing insulation in order to avoid risks due to extremes of temperature. As a further safeguard, should it prove necessary, in the latter connection, the dams can be filled in on the down-stream side, in order to reduce the cost of maintenance. An elevation of the main dam for the western channel is shown in Fig. 1, while Fig. 3 shows a typical section. In this drawing it will be seen that the up-stream face is set at a very considerable slope (actually 45 deg.) and that on the down-stream the buttress is carried up at a steep batter. A dotted line on the up-stream side shows the amount of contemplated filling. Fig. 4 gives a section of the finished dam at the spillway end, at which the concrete structure is surmounted by a wicket weir.

The elevation of the eastern dam is shown in Fig. 5, and three sections are given in Figs. 7, 8 and 9. These are taken through the three discharges, Fig. 7 giving a section of Tunnel No. 1 (Fig. 6), Fig. 9 a section of Tunnel No. 2, and Fig. 8 a section through a smaller tunnel which will always be in service in connection with an hydro-electric installation, arranged under the dam at this point. These tunnels are carried through solid rock, the main discharge tunnels having each a section of 30 sq. m. One of these tunnels suffices for the regulation of the discharge, and the provision of a second is by way of reserve, so that either can be put out of commission should occasion arise. In all three cases shafts are provided on the up-stream side, so that the tunnels can be stopped and dewatered. The main sluices for the discharge tunnels are large rectangular gates fitted with rollers and operated by means of electric winches arranged in houses which have been constructed and finished in the position required for the dam when at its ultimate elevation (see Fig. 29, page 746). These roller sluices are accessible by means of shafts.

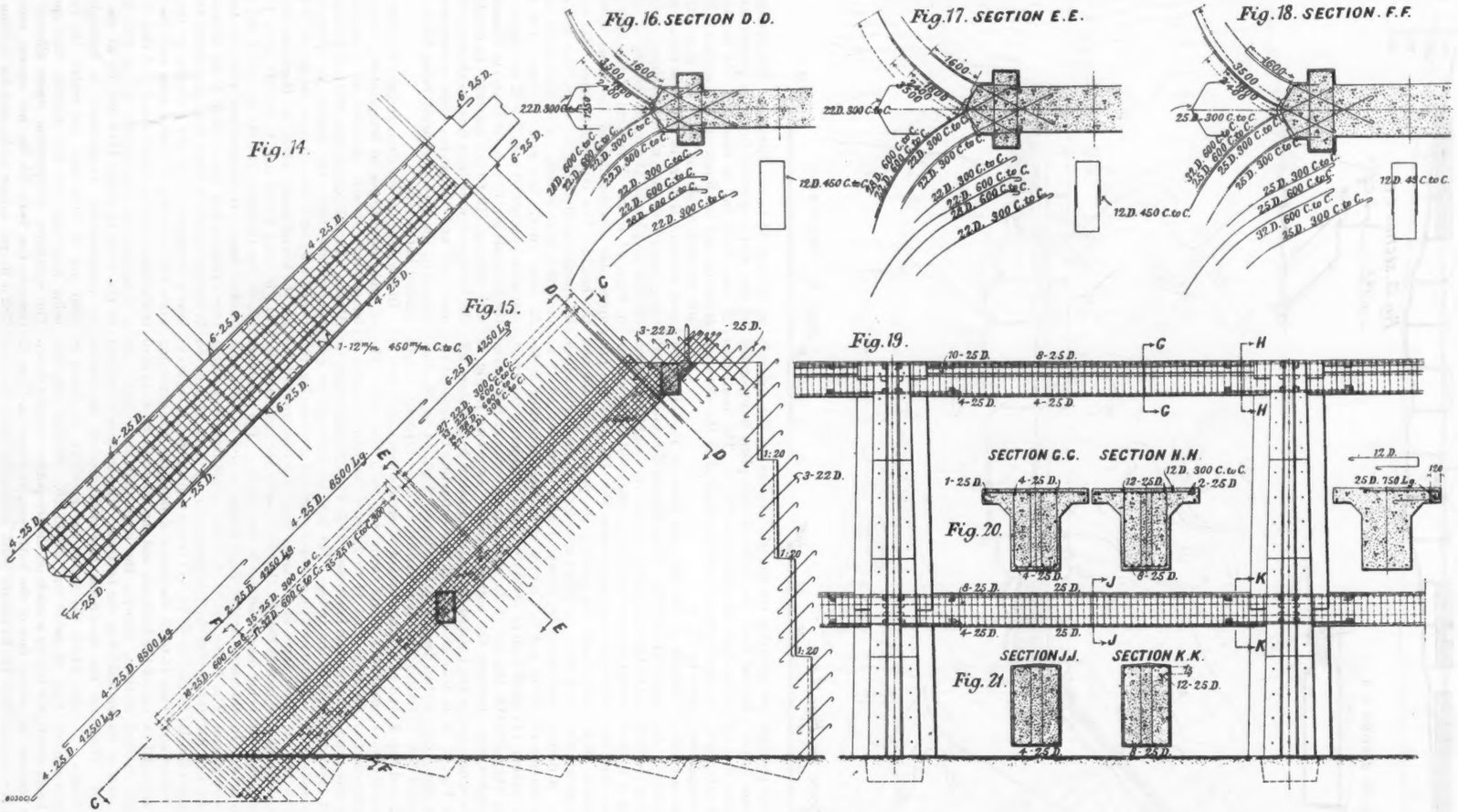
On the down-stream side the two main tunnels each discharge into a pool, a small weir being raised at the lower end of the mouth for the purpose of always retaining water sufficient to fill the tunnel, so as to afford protection to the latter and the sluices from extremes of temperature. The power for operating the electric winches for the sluices is derived from the hydro-electric plant incorporated in the dam, are shown in Fig. 8. The location of the three tunnels is well indicated in the elevation given in Fig. 5.

Details of the dams are given in Figs. 14 to 26, pages 734 and 735. These figures illustrate the work on the first stage only, so that the height and down-stream side are not shown as they will finally appear, while the drawings, such as Fig. 15, show the provision made for bonding the present with the new work when the time comes for the latter to be added. Both dams are provided with buttresses set 12 m. (39 ft. 4·4 in.) centre to centre, supporting arches set at a slope of 45 deg., and of tapering thickness. On the line of the springings a series of ties extend between the buttress walls. As shown in Fig. 3, in the finished dam at its greatest height there will be four lines of such ties extending throughout the arched length of the dams. Figs. 14 to 26, illustrating the dam carried to its temporary height and at a typical point where, however, it is not of maximum height, show two such ties only. The drawings Figs. 14 to 21 show the reinforcement of the ties and buttresses, while Figs. 22 to 26 illustrate that of the arches. The buttress walls are set into the solid rock by means of a series of notches (Fig. 15). They taper in thickness from the base upwards as shown in Fig. 19, the thickness at the foot naturally being dependent upon the height. The minimum thickness at the final height is 0·8 m. (31½ in.). The batter is 50 : 1. The reinforcement bonding the arches to the buttresses by bars 22 mm. to 28 mm. (0·87 in. to 1·1 in.) in diameter, is shown in Figs. 15 to 18, the former showing the bars extending out of the buttress, and the three others, at typical sections, showing the inner and outer arch bars embedded in the buttress. The buttress is finished on the up-stream side with grooved skewbacks into which the arches are moulded, as shown in Figs. 16 to 18 and 24 to 26. Similar provision for keying is made on the temporary stepped down-stream face of the buttresses, as shown in Figs. 15 and 19, to ensure good connection with the new work when added.

The main reinforcing bars in the ties and buttresses are 25 mm. (1 in.) in diameter. The bonding bars let into and projecting from the present work are 22 mm. (0·87 in.) in diameter. At the base the archwork and reinforcement are carried well down into the rock as shown in Fig. 23, page 735. The most economical form of arch was found to be a compromise between a circle and elipse, made up of circular arcs struck at various centres, as indicated in Figs. 24 to 26. The form of the arch on the upper side was maintained the same throughout the height. The tapering thickness was arranged by changes in the radii to which the arcs of the underside were struck. The main arch bars are 22 mm. (0·87 in.) and 25 mm. (1·0 in.) in diameter, spaced 600 mm. (23·62 in.) apart; while the verticals are 12 mm. (0·47 in.) in diameter and with 500 mm. (19·69 in.) spacing. In construction the buttresses were built first, as shown in Fig. 28, page 746, and the arches were constructed subsequently, the load and thrust being taken by the finished buttresses.

In the design of the dam, account has been taken of probable changes of temperature, based upon temperature records observed at Vassijaure and Abisko. In calculating the effect of variations of temperature upon the arches, an allowance has been made, with the reservoir empty, of 15 deg. C. for the lowest parts, where the thickness is 0·8 m. (31½ in.) and for 25 deg. C. for the upper portions where the thickness is 0·45 m. (17·7 in.) in the finished dam. At intermediate points the temperature variation has been taken to be proportional. With the reservoir filled it is considered that the lowest temperature of any concrete in the archwork will be 6 deg. C. below zero, and the lowest temperature of the water about + 4 deg. C., with a difference in temperature of the two surfaces of the work of about 12·5 deg. C., at the lowest air temperature. Contraction in hardening has been put at 0·05 mm. per metre, the concrete being kept wet for two months after pouring. The maximum compression stress allowed in the concrete has been 55 kg. per square centimetre (782·3 lb. per square inch), and for tension in the reinforcement 1,500 kg. per square centimetre (2133·6 lb. per square inch). In America, as

THE SUORVA LAKES DAMS, LAPLAND.



already pointed out, dams of this type have been calculated without reference to ice pressure. At Suorva allowance has been made for this, however, by means of the filling which can be placed in position if thought advisable. This will serve to distribute the load over the structure and reduce local excess pressure. The load which this filling would support without displacement is about 85 tons per metre run, while the greatest load which is anticipated to arise from ice pressure is placed at 60 tons, and this figure has been adopted in the calculations.

The amount of water which will be discharged through the Suorva dam will vary with the amount in storage below, the object being to maintain as large and regular a flow to the Porjus Station as possible. No definite programme will be adopted, however.

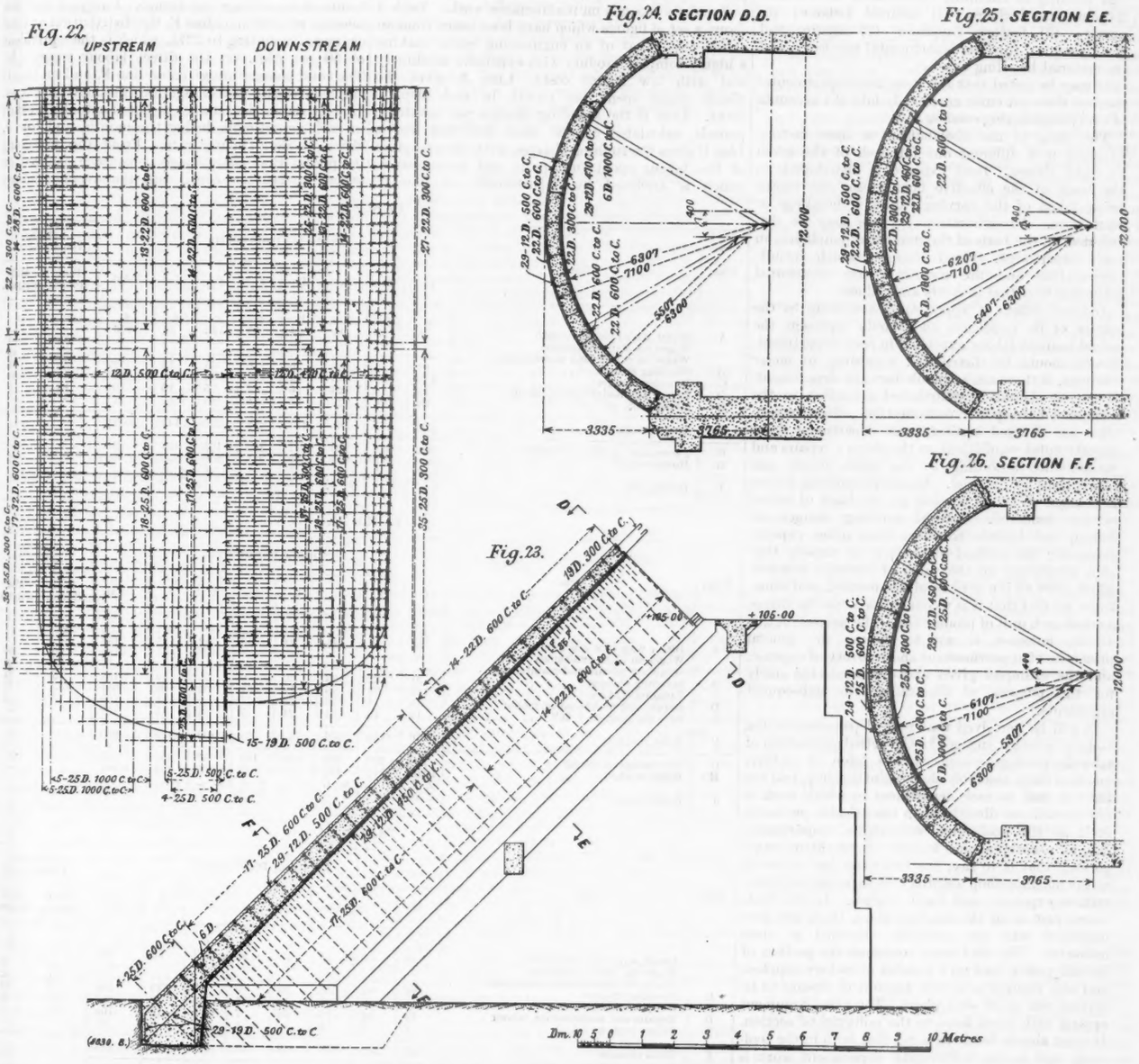
The distance between the Suorva dams and Porjus, the nearest railway station, is about 110 km. (68 miles). Communication is maintained during the summer by means of boats on the intervening lakes, &c. Owing to difference in levels this entails numerous reloadings which greatly delay transport. In winter transport is by sledges, but during the spring and autumn communication cannot be maintained except by aeroplane as the country is impassable. An aeroplane service has proved very valuable in this connection. In winter the machines are fitted with skis, and landings are made on the lakes, the service having been kept up through the coldest weather with temperatures of 30 deg. to 40 deg. C. below zero. In summer the machines are fitted with floats and they alight on the water.

METIS LAKE DAM, CANADA.—According to *The Canadian Engineer*, the damming of Metis Lake, at the head of the Metis River, which was recommended by the Quebec Streams Commission some time ago, and recently approved by the provincial cabinet, will be started early next spring. The enterprise is expected to cost over 200,000 dols., and a contract has been awarded to the Newton-Dakin Construction Company, of Sherbrooke, Quebec. As a result of the construction of the dam, sufficient power will be developed to allow the Lower St. Lawrence Power Company to extend its operations in the lower St. Lawrence District, and electricity will be available, for power and other purposes, in the counties of Rimouski, Matane, Matapedia, Gaspe and Bonaventure.

THE COST OF ACCIDENTS.—It is stated that industrial accidents cost the country 50,000,000*l.* annually, and a very large saving could be arrived at by inculcating the exercise of care and developing knowledge. In one Sheffield steel works which joined the British Industrial Safety First Association in 1919, the number of lost time accidents per 1,000,000 hours worked has fallen from 50 to 28 in 1922, the number of days lost per 1,000 hours worked having decreased from 3·05 in 1919 to 0·7 in 1922. The compensation paid per 100*l.* wages bill was 13*s.* 5*d.* in 1919, falling to 6*s.* 1½*d.* in 1921, the figure for 1922 not being available. In a similar manner for an electrical manufacturing firm in the Midlands, the compensation paid has fallen from 9*s.* 11*d.* in 1913 to 2*s.* 10*d.* in 1921.

THE SUORVA LAKES DAMS, LAPLAND.

(For Description, see Page 731.)



EXPENSE APPORTIONMENT ON ENGINEERING PLANT EXTENSIONS AND MAINTENANCE.

By ROBERT STELLING, F.C.W.A.

WITH the growth of the appreciation of cost accountancy and of its benefits, many books have been written dealing with principal phases of the problem, and the majority of these books have been written with special application to the engineering trades. Perusing this literature, one is able to distinguish the usual characteristics of a probability curve when considering the question of expense apportionment, in that we find the consensus of opinion on the subject of apportionment to productive work in engineering workshops is that such expenses should be distributed and recovered through the cost accounts by means of what is known as the hourly rate system. It is possible to go further, and to make the assumption that the best way of calculating the hourly rate of expense is to classify all the items in seven or eight categories, according to the nature of the business, and these categories again divide themselves into two major sections.

The first of these sections contains what we may describe as the constant or standing charges of the factory. These are the charges which have to be met whether the factory is working at a high or low rate of output, and consequently in their incidence there is very little variation in proportion to the changes in the volume of output. This is not strictly true of certain minor expenses, such as, for instance, the number of telephone calls; and consequently this item of expense under the heading of Postage, Telephones and Telegrams may conceivably increase with the volume of work, and consequently with the number of purchases, with the number of shipments, &c., all of which in these days of rapid transmission of information necessitate frequent telephonic communication. Any cost accountancy system, however, is and must be, of the nature of a compromise, for to get academically perfect analysis and distribution of expense would entail a complexity of organisation and a high salary bill out of all proportion to the value of the results obtained. It is, therefore, agreed by the majority of modern writers on the subject of cost accountancy that it is permissible to regard as constant those items of expense which may be classified as: (1) Rent expense, (2) administration expense, and (3) fixed charges.

The other major section of expense includes those items which may be described as running, controllable or variable charges, and those items of expense which vary with the volume of the output. Here, again, academic theory is limited by practical considerations, for although it is customary to consider these charges in the main as directly proportional to the increase of output, this is not strictly correct. For example, the factory line shafting will always require full lubrication, whether 50 per cent. or 100 per cent. of the machinery driven from that shafting be employed on productive work. On the other hand, with intensive output the repair charges will probably increase, and if careful preparation be made in the accounting system for examining all these items of expense so that executive action can be taken immediately that any unusual incidence

of expense arises, we may for all practical purposes consider that the running charges are proportional to the number of hours of productive work. Under this heading of Running, Controllable or Variable Expense, we include: (4) Indirect Labour; (5) power; (6) factory supplies; (7) repairs and maintenance; (8) interdepartmental services; and (9) material handling expense.

It may be noted that the item interdepartmental services does not enter necessarily into the accounts of every engineering concern.

The basis of the distribution of these factory expenses is a different one for each of the seven or eight classes. Rent expense is distributed on the basis of the effective floor areas, due regard being taken of the varying values of buildings or workshops. Administration expense may be distributed on the basis of the number of employees in each department. Fixed charges, which include depreciation and fire insurance, are distributed according to actual contents and values.

Indirect labour is apportioned according to the nature of its incidence, and should represent the actual indirect labour expended in each department. Power should be distributed according to meter readings, if these are available for each department. If not, it should be distributed according to the estimated horse-power consumption. Factory supplies are charged against each department from departmental requisitions on the stores; repairs and maintenance according to the time sheets and requisitions for material. Interdepartmental service is charged as far as possible on the basis of actual services rendered. Material handling charges are actual, and include transfers from other expense accounts; the method of recovery is usually that of a percentage on the value of material handled, which after all is a very empirical method, and sometimes we find that it is recovered as a specific charge against each unit of production. The purpose of this article, however, is not to discuss the general principles of apportionment and recovery of expense, and the examples given above are selected solely for the purpose of illustrating the subsequent arguments.

It will be perceived that each department in the factory, whether engaged in the actual production of saleable products—such as, the forge or smithy, machine shop, assembly shop, painting shop, and the like—as well as each department in which work is not carried out directly upon the saleable products, such as the tool-room, millwrights' department, &c., all absorb expense included in the above categories; that is to say, the tool-room just as much as the machine shop absorbs rent expenses, administration expenses, and fixed charges. In the tool-room, just as in the machine shop, there are men employed who are generally classified as shop labourers. The tool-room consumes its portion of electric power, uses up a number of factory supplies, and also requires a certain amount of repairs to be carried out to its own plant. The same argument applies with equal force to the millwrights' section. It must also be borne in mind that both in the tool-room and in the millwrights' department work is frequently carried out which is of the nature of an extension to the capital plant of the business, and the cost of this must be added to the capital values of the factory. A question now arises—one which has been the subject of much discussion among engineers, among cost accountants, and also among financial accountants—as to how the expense involved in the running of each of those departments which are not engaged directly upon the saleable products of the firm is to be distributed and recovered.

For the sake of simplicity, this problem will be examined after making certain assumptions. The first is that a time-keeping system exists, by means of which the time of the tool-room staff and of the millwrights is allocated and charged either to plant extensions or to maintenance work. This may conveniently be accomplished with the aid of a system of service orders or of standing orders. It is assumed that the time of these individuals can be allocated and charged against the particular manufacturing department, which is to benefit by their services. This, again, can be easily accomplished when the costs are divided up between plant extensions and maintenance. Another assumption has been made for the sake of simplicity in the tables which follow, namely, that the millwrights spend the same proportion of their total time in the producing departments, or on their behalf, as do the tool-makers engaged on maintenance work. Table I shows a set of figures which have been taken from an actual case—that of an engineering works making a highly complex product with expensive machinery and with low labour costs. Line A gives the direct wages spent per month in each department. Line B the standing charges per month in pounds, calculated on the basis described above. Line C gives the running charges, with the exception of the labour spent in repairs and maintenance, which is analysed by departments on line D. Examining this line it will be noted that 13*l.* has been spent during the month on repairs and maintenance in the tool-room, and 6*l.* has been spent per month in the millwrights' department. Other service departments, such as joiners and electricians, have been omitted for the sake of simplicity, and in considering this table, the labour spent in repairs and maintenance is only considered as that expended by the tool-room and millwrights' staff. It will be noted also that 80*l.* of the tool-room wages are chargeable to plant extensions, as are also 90*l.* of the millwrights.

The first and most usual method of charging the plant extensions account is to consider the direct labour only, together with the material actually used or purchased, as being the amount chargeable to that account. Omitting the question of material, to recover the expenses of the service departments in this case, the usual practice is to take the departmental charges of the tool-room and millwrights' department as given on lines B, C and D, and to distribute these among the charges of the manufacturing departments 1 to 7, proportionally to the direct labour wages expended in these departments at an average percentage. Carrying out this scheme, we obtain on line E, the distribution of total charges, amounting to 227*l.*, which is the equivalent of 50 per cent. on the direct labour wages (A). The total charges are given on line F, and on line G the equivalent percentage on productive wages. Line H shows the number of hours actually worked in each department during the month, and line J, the equivalent hourly rate. From the foregoing it appears that the average percentage charged on labour is 240 per cent., and the average hourly rate is 2*s.* 7½*d.* The charge to the capital account under this scheme, counting direct labour only, will be 170*l.*

This method of charging the capital or plant extensions account with the direct labour and the direct material only is, in reality, insufficient and unsatisfactory. If the firm were purchasing from an outside supplier it would have to purchase the articles at a figure which would include not only the labour and material and profit, but also the establishment charges of the supplying firm. The goods are, therefore, being purchased by the capital account of the purchasing firm from its own tool-room at a figure which is below their real market value. The firm is, in fact, writing down its assets as soon as ever they are acquired, and the resulting influence upon the cost of production will be shown after considering the Tables II and III.

The second method of treatment to be considered is that in which the ratio is taken of the total

TABLE I.

Line.	Item.	Producing Departments. 1.	2.	3.	4.	5.	6.	7.	Total.	Service Departments. Tool Room.	Millwrights.
		£	£	£	£	£	£	£	£	£	£
A	Direct wages for one month	58	53	44	24	50	192	35	456	—	—
	Wages on plant extensions	—	—	—	—	—	—	—	—	80	90
	Wages on repairs and maintenance	—	—	—	—	—	—	—	—	81	42
B	Standing charges	31	32	33	30	9	35	19	189	35	24
C	Running charges	110	99	85	79	31	64	89	557	113	36
D	Repair and maintenance, labour	15	14	26	26	7	5	16	109	13	6
E	50 per cent. on "A"	29	26	22	12	25	96	17	227	—	—
F	Total charges	185	171	167	147	72	200	141	1,083	—	—
G	Percentage on labour (direct)	320	325	380	612	144	105	404	240	—	—
H	Hours worked	1,200	940	942	570	846	3,060	750	8,308	—	—
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.			
J	Hourly rate	3 1	3 7	3 6½	5 2	1 8½	1 3½	3 9	2 7½		

TABLE II.

Line.	Item.	Producing Departments. 1.	2.	3.	4.	5.	6.	7.	Total.	Service Departments. Tool Room.	Millwrights.
		£	£	£	£	£	£	£	£	£	£
A	Direct wages for one month	58	53	44	24	50	192	35	456	—	—
	Wages on plant extensions	—	—	—	—	—	—	—	—	80	90
	Wages on repairs and maintenance	—	—	—	—	—	—	—	—	81	42
B	Standing charges	31	32	33	30	9	35	19	189	35	24
C	Running charges	110	99	85	79	31	64	89	557	113	36
D	Repair and maintenance, labour	15	14	26	26	7	5	16	109	13	6
E	93·5 per cent. on "D"	14	13	24	24	7	5	15	102	—	—
F	Total charges	170	160	168	159	54	109	139	959	—	—
G	Percentage on labour	293	302	392	663	108	57	397	210	—	—
H	Hours worked	1,200	940	942	570	846	3,060	750	8,308	—	—
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.		
J	Hourly rate	2 10	3 4	3 6½	5 7	1 3½	0 8½	3 9	2 1	—	—

TABLE III.

Line.	Item.	Producing Departments. 1.	2.	3.	4.	5.	6.	7.	Total	Service Departments. Tool Room.	Millwrights.
		£	£	£	£	£	£	£	£	£	£
A	Direct wages for one month	58	53	44	24	50	192	35	456	—	—
	Wages on plant extensions	—	—	—	—	—	—	—	—	80	90
	Wages on repairs and maintenance	—	—	—	—	—	—	—	—	81	42
B	Standing charges	31	32	33	30	9	35	19	189	35	24
C	Running charges	110	99	85	79	31	64	89	557	113	36
D	Repairs and maintenance, labour	15	14	26	26	7	5	16	109	13	6
E	56 per cent. on "D"	7	7	14	14	4	3	8	57	—	—
F	Total charges	163	152	158	149	51	107	132	913	—	—
G	Percentage on labour	280	297	360	620	102	56	377	200	—	—
H	Hours worked	1,200	940	942	570	846	3,060	750	8,308	—	—
		s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.		
J	Hourly rate	2 8½	3 3	3 4	5 3	1 2½	0 8	3 6½	1 10	—	—

expenses of the service departments to their own labour wages. The direct wages expended on plant extension and on maintenance are separated, and the expenses are divided among them *pro rata*. As the wages expended on maintenance work are divided among the manufacturing departments, according to the record of time spent therein or on their behalf, the proportion of service department expense which relates to maintenance work must be apportioned to the manufacturing departments *pro rata* to the maintenance wages.

Following out this argument in conjunction with the actual example, we find that in the case of the tool room 161*l.* is incurred in expenses, and in the millwrights' department a corresponding expense of 66*l.* Apportioning the expense to the wages on plant extensions and to the wages on repairs and maintenance, we arrive at the figures of 81*l.* and 21*l.*, which are the charges of the tool-room and millwrights' work respectively, to be recovered from the producing departments, in respect of the expenses incurred in carrying out the repair and maintenance work. It has been stated above that for the sake of simplicity it is assumed that the millwrights spend the same proportion of their total time in each of the producing departments, or on their behalf, as do the tool-makers engaged on maintenance work. Therefore, it is correct to add these two sums; namely, 81*l.* and 21*l.*, together, giving a total of 102*l.*, and charge the total amount, as in Table II, line E, to the producing departments 1 to 7 in the ratio of 102 to 109; that is to say, as 93·5 per cent. on the figures in line D. There remains a balance of 125*l.* of the charges of the service departments, which in turn becomes the charge to be debited to the cost of the capital extensions. Line F, Table II, shows the total charges against each manufacturing department resulting therefrom; lines G, H and J corresponding to Table I. It will be observed that the average percentage to direct labour wages is 210 per cent., and the average hourly rate is 2*s.* 1*d.* per hour. The amount to be charged to the plant extensions account under this scheme is 170*l.*, plus 125*l.*, equals 295*l.* We have now approached a far more reasonable basis for charging the plant extensions account, for in the cost of the items charged thereto, a fair share of the departmental and factory expense has been included.

It is argued by some that this does not go far enough, for an establishment charge on the repair work and maintenance work for the tool-room and millwrights' departments has not been included. Moreover, the cost of the article is still considerably below the price it would be necessary to pay if the article were purchased outside. Arguing on these lines, it is often the practice to assume a higher percentage on labour expended on plant extensions by the tool-room or millwrights than is given by the analysis of the actual figures.

Following out this line of thought, an example is shown in Table III, in which case an expense charge of 128 per cent. is assumed on the tool-room labour on plant extension, and a corresponding charge of 75 per cent. on millwrights' labour, also on plant extension. Working this out, it follows that 102·5*l.* (approximately) plus 67·5*l.* equals 170*l.* of the total expense incurred during the accounting period will be charged against the plant extension, and that of the total of the charges incurred by the two departments, namely, 227*l.*, only 57*l.* remains to be recovered from the producing departments *pro rata* to the wages incurred on maintenance work. Again, following out the argument used in connection with Table II, this sum of 57*l.* is distributed among the seven departments in the ratio of 57 to 109, or as 56 per cent. on the items for repair and maintenance labour in line D. The lines F, G, H and J correspond again to Table I. It will be observed that the percentage ratio of charges to direct labour averages 200 per cent., the average hourly rate 1*s.* 10*d.* per hour, and the amount which would be charged to the plant extensions account would be 80*l.* plus 102·5*l.* plus 90*l.* plus 67·5*l.*, equals 340*l.*

The effect upon the cost of production can now be easily observed by comparing the figures in the total column of lines G and J. The percentage on labour, as shown in the total column of line G, is 240, 210 and 200, according to the choice of the method of costing the work of the service departments. Adding 100 in each case as being the direct labour charges, it follows that the cost of production, as far as labour and charges is concerned, varies in the order of 340, 310 and 300; very appreciable differences which may seriously affect quotations in keen competition.

In the opinion of the writer, the method indicated in Table II seems to be the most logical and satisfactory, for the true cost of manufacturing is kept separate, and a truer value of the assets placed to the credit of the plant extension account is obtained than by either of the other two.

NOTES ON NEW BOOKS.

THERE is a great difficulty in producing a treatise on electro-technics that meets both the needs of the amateur who finds the popular description unsatisfactory and at the same time fulfils the requirements of the man, who, having read, and possibly forgotten much of, his mathematics, desires to master thoroughly the fundamental principles that determine practical application. We cannot say that Mr. Edgar T. Larner, in his "*Radio and High Frequency Currents*" (Crosby, Lockwood and Son; price 3*s.* 6*d.*) has fully met the situation. This in a great measure may be due to the brief treatment of a wide subject. Using the arrangement of headed and numbered paragraphs, the reason for the selection of each and the connection between them are not fully perceived, and it is difficult to follow the argument in its integrity. The book is intended for those who possess some knowledge of electricity and mathematics, and the mathematician must be supposed to be better equipped than the electrician. With the scant information provided, very considerable training is needed to gain any real information from the form of such an equation as

$$h_s I_s = \frac{\lambda d R I_r}{377 h_r} \sqrt{(\sin \theta/\theta)} \epsilon 0{\cdot}0015 d/\sqrt{\lambda}$$

flung at the reader as it is without adequate preparation. To handle the equation as an assembly of algebraical symbols is not difficult, and one may convince oneself that it has been derived according to known rules, but that is very different from having such familiarity and mastery of the subject, as to be able to use similar reasoning as steps towards unravelling an involved problem. The electrician, the man who wants to understand and to use his instrument to the fullest advantage is better catered for. He will learn something practical about electric waves and their means of propagation, while in three other chapters he is introduced to the purpose of condensers and the operations of tuning and coupling. This preliminary information leads to the possibilities of reception, the action of crystal detectors and, of course, a more or less complete description of the triode valve. It is a bold programme to attempt to discuss characteristic curves in such a small space, but so far as the explanation goes it is very well done, and one wishes the author had allowed himself to write more fully. A page or two is given to the subject of continuous waves and the heterodyne method of reception. The last chapter is devoted to transmission in which we meet the triode again as a generator. High frequency alternators are mentioned and the mechanism of the Poulsen transmitter is explained.

About a quarter of a century since, M. and Mme. Curie succeeded in isolating radium salts, and provided the material for examining those spontaneously emitted penetrating rays, whose study has revealed new properties of matter. Since that time, workers have been many and the harvest abundant. Investigation has led in so many directions, and so many new facts have been discovered and harmonised, that the layman needs a guide to the scientific labyrinth, from which issue avenues that lead to the most fascinating developments of physical and chemical science. A very capable guide is found in Professor Fajans, of Munich, whose work on "*Radioactivity*" (Methuen and Co., London; price 8*s.* 6*d.* net) has been translated by Messrs. T. S. Wheeler and W. G. King. The translators have used the fourth German edition (1922) and the frequent issue of successive editions is a proof of the rapid accumulation of facts and of the eagerness of the public to be put in possession of the latest information. That this work has been brought down as nearly as possible to date is shown by the inclusion, in an appendix, of the discovery of hafnium, by Messrs. Coster and von Hevesy, and a discussion on a hitherto unpublished "Law of Instability." It is no small feat to give a comprehensive account of this branch of physical science, that starts from the discovery of Becquerel and ends with the detection of a new element that gives an interesting confirmation of Moseley's brilliant deductions from his work on X-ray Spectra. How much the distinguished professor has been able to cover, we shall appreciate if we recall the early history of radioactive bodies and their transformations; their classification in the periodic table, the substitution of the atomic number for the atomic weight as affording the better fundamental characteristic; Aston's work on isotopes; the structure of atoms and their artificial decomposition; and not least the evidence of their complicated structure which has found an intelligent if temporary, explantion in the models of Rutherford and Niels Bohr. The side issues that have been raised are not less important than the main line of investigation. We have seen classical dynamics strained to its utmost to furnish plausible hypotheses, and ingenuity perhaps triumphing over demonstration. The author maintains that it is possible to reconcile the whole phenomena of radioactivity and their deductions with classical physics, and that no previously accepted axiom has had to be reconstructed. If any uncomfortable contradictions remain, it is chemistry that has to bear the brunt. We bow to the professor's assertion, but it is unfortunate that two kinds of atoms hold the field. The physicist is satisfied with the dynamical atom, which he has fashioned to fit his requirements, on the other hand; the chemist with his molecule demands a static atom. While we are allowed a choice, one cannot but distrust the accuracy of the conclusions, which depend on rather frail hypotheses. Possibly, we are trying to force an agreement between ascertained facts and the framework we have constructed to fit them. The difficulties may be of our own making and may disappear before simpler conceptions, as the cumbrous system of "cycle and epicycle" fell before the assaults of Kepler and Newton.

Dr. Ing. Werner von Langsdorff, editor of the German pocket book of air fleets (*Luftflotten*), the publication of which, interrupted by the war, was resumed last spring, has also compiled a volume on sailing flight under the title, "*Das Segelflugzeug*" (München: J. F. Lehmann; price 3*s.* 6*d.*). The book is of real pocket-book size, about 7½ in. by 5 in. But there are 217 pages and 114 text figures, and the type is small, so that the volume, which is provided with a good index, contains more than one expects even after a first glance. The book deals with all flying craft which do not depend upon motive power, and it devotes more attention to general features and constructive detail than to theoretical considerations. Nearly half of the space available is taken up by a summary of the particulars of gliders of the last few years, references to 1922 and 1923 being most frequent. The Itford trials of October, 1922, and the competitive flights which took place at Biskra, Algiers, in May, 1923, are duly noticed. In the former instance, 4 pages are given to a description of the Peyret-Putiaux tandem monoplane on which Maneyrol (since killed at Lympne) was able to beat the German records; that, however, is an unusually large space allowance, most machines getting only about a page. Noteworthy trial achievements are specified in the accounts. W. von Langsdorff, himself an aviator, though apparently not practised in gliding, does not suggest that gliding flight has solved the main difficulties. He records what has been done since Otto Lilienthal lost his life in 1896, and the means by which that has been achieved.

If the methods of costing the work done in the different departments of an engineering works were examined, for the purpose of ascertaining in which of these the resultant figures most nearly reflected the facts, it is not improbable that those used in the foundry and smithy departments would be found the least satisfactory. That delightfully simple and easy method of lumping all expenses together, and apportioning them over the total weight produced at a flat rate per pound, is still in use and, because all expenses can be proved to be absorbed thereby, is held to be efficient. Just how far from the truth the resultant figures may be, will depend upon the variation in the classes of work handled, a fact which is evidently appreciated by the authors of "*Cost Control for Foundries*," F. C. Everitt and Johnson Heywood, published by the McGraw Hill Publishing Company, Limited, 6 and 8, Bouverie-street, London, E.C. 4 (price 15*s.* net). The first chapter is devoted to explaining what a cost system can do. The importance is emphasised of using right methods so that the detailed costs will be correct as well as the overall expenditure accounted for, the fallacy of the flat cost per pound method being shown up at the same time. In the second chapter, the "fundamentals of costing" are discussed under the three heads of material, labour, and on-costs, the various steps necessary to bring these into the finished costs being traced. In dealing with the question of on-costs, the inaccuracy of apportioning these on a flat basis as of labour only, is shown, and it is recommended, and the reasons for doing so are given, that overheads—on-costs—should be departmentalised, as for example, core room, moulding, melting, &c. There is no doubt that the recommendation is on the right lines; the

information which would be disclosed would be a most valuable index as to the manner in which on-costs grew and, also, could be controlled, and the larger the foundry, the more important would the need for such information become. It is feared, however, that to many founders, this will appear to be a gospel of perfection, which would be costly rather than remunerative. The method of arriving at the cost of castings is quite well treated and attention is drawn to the inaccurate results which can follow the use of percentages and averages when different classes of castings are being handled, as, for example, gates and sprues (runners) on light and heavy castings. Altogether, the subject is well covered, the treatment being in no sense dogmatical. Various forms are given indicating the methods by which costs can be built up, and any founder, who is desirous of checking his methods of costing, or of improving them, can rely upon getting some assistance from a perusal of this book. The authors finish up by saying "you must use your costs." The probability is that if costs were considered as being more than an accounting requirement only, and were used more for administrative purposes than they are, the real value of the possibilities of costing systems would be better appreciated.

We have received two publications of the Encyclopédie Léauté series, on modern processes in the gas industry. Their titles are "*Distillation de la Houille*" and "*Traitement des Produits et Sous-Produits de la Distillation de la Houille.*" The authors of both the volumes (Paris: Masson and Cie., and Gauthier Villars and Cie; price in France 20 francs) are René Masse, late Président du Syndicat Professionnel de l'Industrie du Gaz, and Auguste Baril, of the Société d'Eclairage, Chauffage et Force Motrice. The authors give a general survey of the present state of the gas industry written, as one would expect from a volume of an encyclopædia series, for the student and general reader rather than for the specialist; as such the volumes are quite acceptable. There is ample technical detail and tabular matter, though hardly enough to justify the claim made in the preface that the reader seems to be introduced into works instead of into books. References are scanty. The French classification of coals as to flame length in its connection with composition, nature of coke, calorific power, &c., is declared to be superior to that of other countries; but we are not sure that this classification originated in France, and it is certainly not peculiar to France. The main parts of the second volume deal with the treatment of coal gas, its measurement and tests, recovery of benzene and ethylene, and the treatment of the coke, the ammonia liquor and the tar. Dye stuffs are not mentioned, nor are unsaturated compounds, and there are only three pages on oils. The indices hardly do justice to the contents of the volumes.

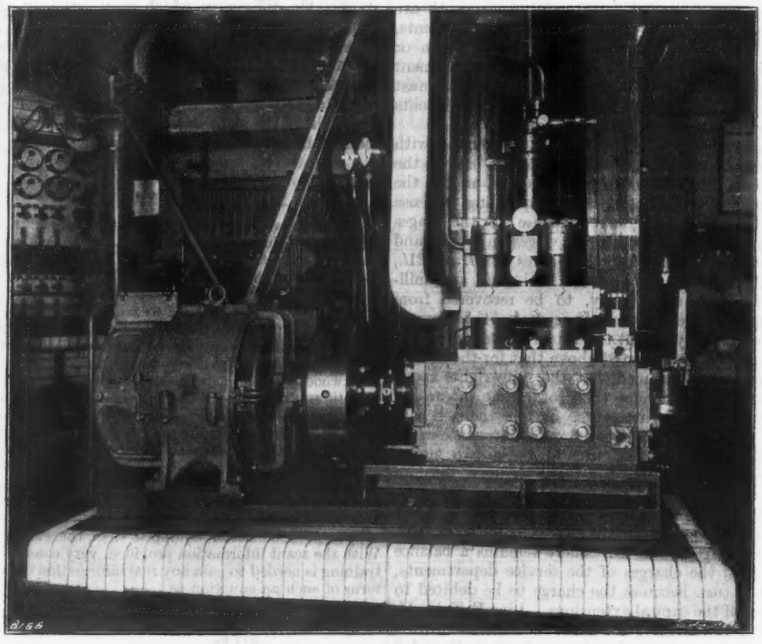
TEN-TON REFRIGERATING CO_2 COMPRESSOR.

An example of a new design of CO_2 compressor which has been introduced by Messrs. H. J. West and Co., Limited, of Gray's Inn-road, London, W.C.1, and Saxilby, Lincolnshire, is illustrated above. As will be seen the machine is of the twin-cylinder single-acting vertical type. It has a capacity of 10 tons of refrigeration per 24 hours and is driven by a 20 b.h.p. electric motor which runs at 400 to 500 r.p.m. The motor and compressor are mounted on a common cast-iron bedplate. By dividing the work of the compressor among two cylinders of relatively small dimensions a comparatively uniform driving torque is obtained. The machine is well balanced and there is practically no vibration. The special features of the compressor lie in its mechanical construction, the crank case, cylinders, manifolds and fittings being machined from solid steel forgings.

Each cylinder consists of a separate alloy steel forging and is of uniform sections throughout. The operations of boring and facing each cylinder are performed at one setting and all working surfaces are ground. Each cylinder is provided with a West patent safety head, which forms the top of the cylinder and houses the discharge valves. The head is normally held in position on its flat ground seating by strong compression springs and is free to move vertically when subjected to excessive pressure, thus providing additional clearance space at the top end of the cylinder for the passage of excess of liquid without injury to the cylinder or motion gear. The arrangement also prevents damage to the cylinder in the case of such an emergency as a broken suction valve. The pistons and crossheads are cast in one piece and take the form of long trunks which have a very liberal bearing surface, eliminating local wear of the cylinder walls and ensuring gas tightness. Under normal operating conditions the pressure of the crosshead on the cylinder walls, due to the maximum obliquity of the connecting rod does not exceed 12 lb. per square inch of projected

TEN-TON REFRIGERATING CO_2 COMPRESSOR.

CONSTRUCTED BY MESSRS. H. J. WEST AND CO., LIMITED, ENGINEERS, LONDON.



area. The pistons are fitted with seven cast-iron rings, and two additional oil-scraper rings are fitted in the crosshead below the gudgeon pin. The scraper rings do not over-run the CO_2 induction ports. The gudgeon pin, which is of high carbon steel, is a driving fit in the crosshead and is secured radially by a sunk key, and axially by a taper and lock nut. The pressure on the bearing does not exceed 550 lbs. per square inch of projected area.

The suction valves are of the flat ring plate type, forged from carbon steel. After machining, they are heat treated, normalised and finished true to gauge by grinding. They are located in the head of the piston, where they have the full diameter of the piston for their accommodation, and operate vertically without springs, detachable lift stops or other moving parts. The valves are of sufficient area to allow of a mean gas velocity not exceeding 30 ft. per second when the lift is $\frac{1}{32}$ of an inch. They operate by their own inertia without wiredrawing or reduction of pressure below that obtaining in the induction passage. The valves are given a continuous rotary motion, which makes them self-grinding and self-cleaning, while they can be withdrawn from the cylinder for inspection or adjustment without withdrawing the piston. The discharge valves are of the same ring plate type as the suction valves and are located in the safety head. They are provided with high-compression springs to ensure instantaneous closing and are of sufficient area to allow of the compressed gas being discharged, without shock or excess pressure, at a mean velocity of 30 ft. per second.

The crankshaft is of Siemens Martin steel forged solid in one piece and machined all over. The cranks are arranged at equal angles and each crank has a main bearing at both sides. The maximum pressure on the main bearing does not exceed 100 lb. per square inch of projected area. A separate ring-lubricator outboard bearing is provided to carry the tail end of the shaft and support the fly-wheel and coupling, thus relieving the main bearings in the crank case from all work except that due to the thrust of the connecting rods. These rods are of circular section, both the large and small end being forged solid with the rods. The small ends are fitted with renewable Babbitted steel bushes, the large ends being lined with Babbitt metal and having a maximum pressure on the crank pin not exceeding 100 lb. per square inch of projected area. The crank-case motion-work and bearings are completely enclosed in a steel block crank-case, which is bored from end to end in one setting to form seatings for the main bearings. Bored facings are provided at the top upon which the cylinders are bolted. Large inspection doors are provided on each side of the crank-chamber and thick glass observation windows are arranged on both sides through which the oil-level may be seen at any time. One end of the crank-chamber is closed by a removable cover for withdrawing the crank-shaft, while the other end is fitted with an oil-sealed shaft gland continuously supplied with oil under pressure from the lubrication system. It will be seen that the enclosed construction necessitates only one gland of a simple type for the CO_2 cylinders and that this gland is only subjected to the suction pressure in the crank-case and not to the high pressure CO_2, as is the case with the reciprocating piston-rod glands of a horizontal or vertical double-acting compressor.

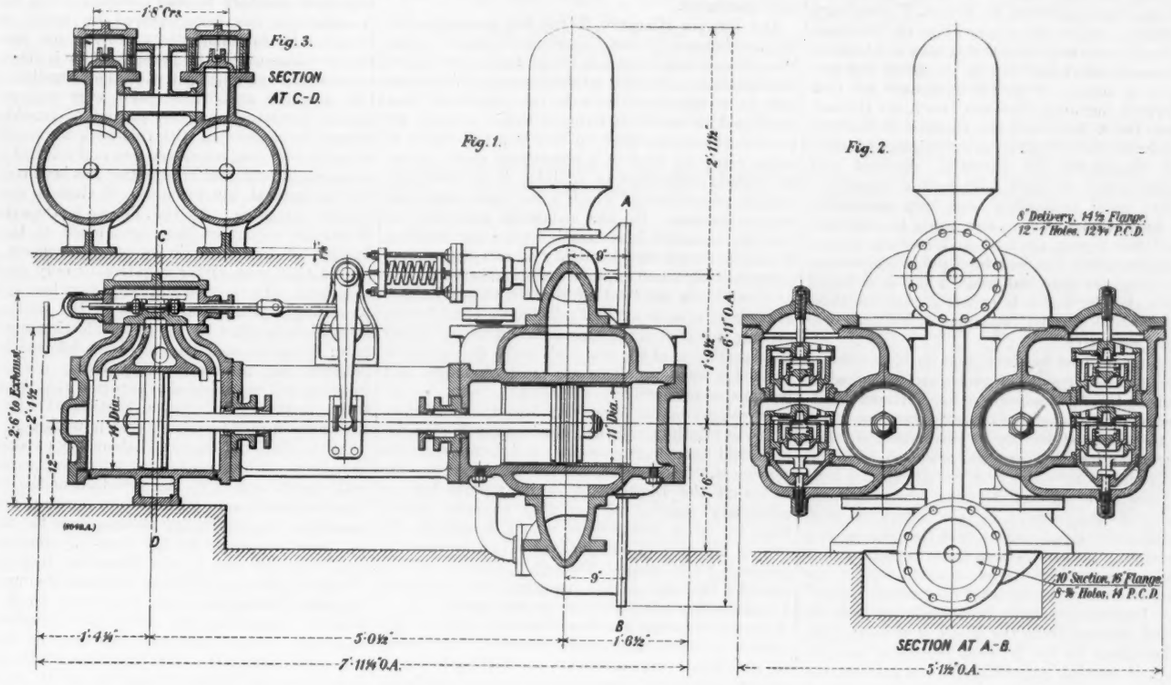
All bearings and working surfaces inside the crank-chamber are continuously flooded with oil under pressure from a rotary valveless oil pump of the gear wheel type which is fixed in the crank chamber and is direct driven from the free end of the crank-shaft. The oil which is squeezed out of the bearings falls into a sump in the lower part of the crank-case from where it passes through a gauze strainer before returning to the pump for re-circulation. The compression cylinders are connected together on the suction side by a cast-iron induction header, protected at its entrance by a strainer which is arranged for removal and cleaning without disturbing any pipe connections. The discharge header coupling the outlet ports of the cylinders is of steel and terminates in an oil separator. All CO_2 stop valves are fitted with spindle glands arranged for repacking under pressure when necessary, while pressure gauges are arranged for the induction and discharge sides of the compressor. A number of machines of this new type up to a capacity of 25 tons have been constructed, or are being constructed, by Messrs. West.

Aluminium Alloy Road Wheels.—The London General Omnibus Company Research Department have been experimenting with an aluminium alloy road wheel, which although only half the weight of the standard steel wheel, has given exceptionally satisfactory results. A number of these wheels have now performed over 30,000 miles in service, and tests are continuing on upwards of 20 routes. The economical advantage which the aluminium wheel possesses is that the scrap value is about two-thirds of its original casting value. A further great advantage is the big reduction in unsprung weight and the minimising of road destruction.

South-West Africa Tin.—According to a message from Windhoek, says *The South African Mining and Engineering Journal*, considerable activity is evidenced on the tin mines in Karibib district. A German company, South-West African Mines, Limited, has been doing a considerable amount of work since February, 1922. The output for nine months in 1922 was 40 tons, and 43 tons have been produced in 1923. The company is obtaining a concentrating plant from Germany, which is expected to be in operation by April next, with a minimum output of 10 tons monthly. The ore in sight will last for many years. The operation of a smelting plant is contemplated in the future if circumstances permit.

HORIZONTAL DUPLEX CARGO OIL PUMP.

CONSTRUCTED BY MESSRS. WORTHINGTON-SIMPSON, LIMITED, ENGINEERS, NEWARK-ON-TRENT.



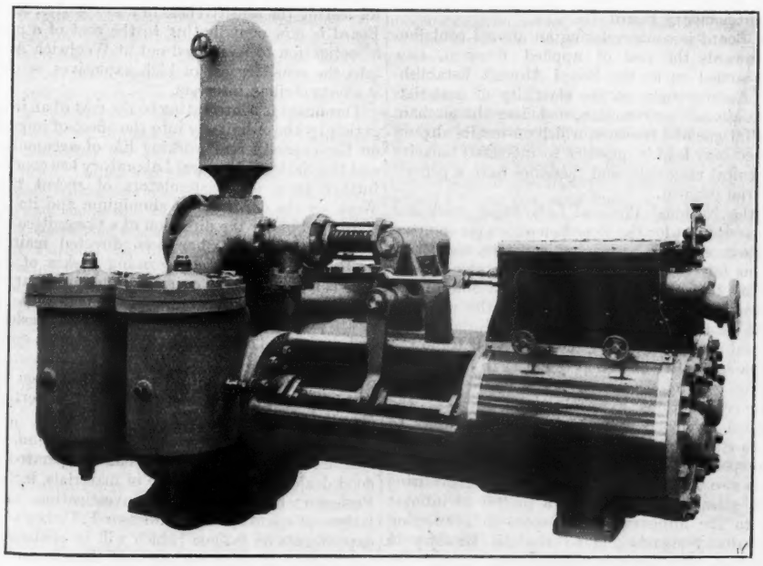


FIG. 4.

A LARGE range of direct-acting pumps of various types is manufactured by Messrs. Worthington-Simpson, Limited, of Queen's House, Kingsway, London, W.C.2, and Newark-on-Trent. Many of these are designed for special service, and an interesting example of such a pump intended for dealing with oil cargoes in bulk is illustrated in Figs. 1 to 4 above. The pump is capable of dealing with 200 tons of crude oil per hour and will deliver against a pressure of 250 lb. per square inch. The pump piston is 11 in. in diameter and the steam piston 14 in., the common stroke being 15 in. The steam pressure is 180 lb. per square inch. The arrangement of the pump is well shown in Figs. 1 and 2. It is of the pot valve type and is fitted with the maker's patent stream-line valves, one suction and one delivery valve being placed in each pot. Each of the suction and delivery valves is made so that they form independent units, the valve seat being included in the unit. The valve units are each carried on ring seats which are fitted into the casing. These ring seats can be easily replaced in case of corrosion. It not infrequently happens that a pump is required to deal with oil containing some ingredient which has a corrosive effect, and in such cases the possibility of replacing the ring seat rather than the whole valve chamber is an important one, both from the points of view of convenience and expense.

Generally, the pump is fitted with brass pistons and rods and the barrels are provided with brass liners, while the valve parts are of gun-metal. If, however, this construction is objectionable on account of the nature of the oil dealt with, these parts may be made of iron and steel. The pump has a 10-in. suction and an 8-in. delivery, and as will be seen from Figs. 1 and 4 is fitted with a relief valve on the delivery side. The steam end is of standard form and is clearly shown in Figs. 1 and 3.

THE LATE SIR T. L. DEVITT.

BRITISH shipping and the British seaman have lost an old and valued friend by the death of Sir T. L. Devitt, which occurred on the 8th inst. Sir Thomas was born in 1839, and at the time of his death had withdrawn from most of his business activities, but his interests in shipping and in seamen were retained to the end. He was prominently associated with the Australian shipping trade, and his firm Messrs. Devitt and Moore some years ago had a very fine fleet of sailing ships engaged in this trade. The firm was also connected with steamer traffic to the same part of the world, and Sir Thomas was closely connected with the Orient Steam Navigation Company. The problem of the training of steamship officers was one in which Sir Thomas took a great interest, and some twenty-five years ago, in conjunction with the first Lord Brassey, he established a training scheme for future officers in connection with sailing vessels belonging to Messrs. Devitt and Moore.

The interests of seamen was a subject which was never far from Sir Thomas' thoughts, and he played a very practical part in many charities established for seafaring men. He devoted much time and attention to the Royal Merchant Seamen's Orphanage at Snaresbrook, and, in conjunction with Sir Alfred Yarrow, presented the institution some years ago with the new premises it now occupies at Bearwood in Berkshire, while in quite recent years the Nautical College at Pangbourne for the training of cadets owed to him its successful establishment. Sir Thomas was president of the Chamber of Shipping of the United Kingdom in 1890, and was for some years chairman of the Shipping Federation and of the General Shipowners' Society, of London. He was closely connected with Lloyds, being elected an underwriting member in 1886 and holding the position of chairman from 1909 to 1920. It was largely owing to the initiative and influence of Sir Thomas that a practical shipbuilder and engineer—Lord Pirrie—was placed in charge of merchant shipbuilding during the war. This incident showed his practical interest in shipbuilding and engineering matters, and this was further illustrated by his connection with the Institute of Marine Engineers and the Institution of Naval Architects. He was president of the former body in 1913, and was a vice-president of the latter at the time of his death.

THE SCIENTIFIC AND INDUSTRIAL RESEARCH DEPARTMENT 1922-23.

(*Continued from page* 658.)

Building Research Board.—A fundamental research has been conducted by Miss E. T. Bradbury and others, under the supervision of Professor C. H. Desch, into the processes of setting and hardening of cements, and another into the decay and preservation of stone. A special committee has now been formed, including Professor Desch, Sir Herbert Jackson, Dr. A. Scott and the Director of Building Research (Mr. H. O. Weller), to investigate the latter subject thoroughly by chemical, physical and biological work. A third fundamental research—that into paint technology—has been suspended, partly for financial reasons, and partly to await the Home Office report on lead and leadless paints. This report, which has now been published, recommends extensive practical trials, which it is hoped to begin shortly, but it is expected that for these to be effective parallel fundamental research will be found necessary.

Considerable work has been done on blast-furnace slag cement, the results of which are embodied in the new B.E.S.A. specification for Portland blast-furnace cement, a substance of which the value seems likely to be limited less by its intrinsic merit than by the quantity that can be produced. Several special cements have also been examined, and tests have been made on high alumina cement (ciment fondu, "electric cement,"), the effect of high magnesia in Portland cement, and the permeability of concrete. Determinations have been made of the modulus of elasticity of concrete and of the various reinforcing steels used in making "spun" pipes. Experiments have been made on tests for Portland cements, with the object of making them less dependent on the personal equation, into the dangers of asbestos cement roofs, and into the use of waste materials in cement making, the last of which has led to making a good puzzolanic cement out of spent oil shale. Work has also been done on magnesite cements (jointless floors), and a cement has been produced that is non-corrosive to metals. A special report on work done for the Board by Dr. Ezer Griffiths on the conductivity of building materials has been published (*cf.* Engineering, page 338). When Dr. Griffiths visited Australia for the Food Research Board, satisfactory solar radiation tests were made on some 20 specimens of roofs prepared at the Building Research Station at Acton, and a report is in preparation. A waterproof distemper, required through the porosity of poor concrete and porous stone, has been made and has been successful in several parts of the country, and several colourless waterproofing solutions were worked out at the same time. A research has been made, under the supervision of Dr. J. W. Mellor, into the economical firing of brick kilns, especially by gas, others under Dr. Stradling into the behaviour of Portland blast-furnace cement under fire tests and the artificial maturing of concrete, and another under Professor Perrott into the weathering of bricks and tiles. At the request of the Royal Institute of British Architects, some work is being done, though as yet not on any large scale, on the acoustics of large buildings, and some tests on the lines of the late Professor Sabine's work are being made at the request and expense of the Government of India. In its wider aspects the problem is also being considered by the Physics Co-ordinating Board. Owing almost entirely to financial reasons little work has been done on methods of construction.

The Board has found compensation for the small size of its Acton station in the increased facility with which the work of chemist, physicist and engineer can be co-ordinated in individual problems, such as the preparation of a standard specification, and in the wider range of plant and expert assistance to be found in extra-mural establishments.

Assistance has been given to several other public departments and to other research boards and committees of the Department, and the Director has served on a number of departmental and other bodies outside the Department. In all eight reports have now been published.

Physics Co-ordinating Research Board.—The several items of the work of the Co-ordinating Research Boards, though it is mostly allied to the work of other branches of the Department and of the institutions with which it co-operates, have the special interest that they serve, so to speak, to plot out the sphere of their actions, and to indicate how they fill a gap that was left open before they were instituted.

The Physics Research Board has recommended the continuance of the Department's grant to the War Office towards work in the acoustical section of the signals experimental establishment at Woolwich, and in co-operation with it the Admiralty has continued its work on fixing a ship's position by a radio-acoustic method up to a point at which it seems ready for trial on a commercial scale, except for certain difficulties in applying it to passenger vessels, on account of which it has been postponed for the present. On the acoustical properties of building materials it is examining for the Building Research Board the possibility of carrying out at comparatively small expense investigations that will give architects practical information that is lacking at present, so as to avoid if possible the considerable expense involved in the special experimental rooms and large areas of the materials under investigation by which such problems are most obviously, and perhaps most effectively, attacked.

Investigations at Woolwich into the possibility of using selenium cells as detectors for X-rays did not yield encouraging results, and have been discontinued. The statement recalls, however, the fact that the Department in its reports has an exemplary practice of recording negative results that in other institutions would sometimes be merely disregarded, leading other investigators to go over futile ground through ignorance of the warning that the earlier investigation had given. In connection with its work on the production of X-rays and screens the Board has arranged for the British Scientific Instrument Research Association to investigate on its behalf general problems of phosphorescence, a subject allied to that of luminous paints, which the Association is already investigating for the Chemistry Board.

The Board is contemplating an annual contribution towards the cost of applied research, now being carried on at the Royal Aircraft Establishment, Farnborough, on the elasticity of materials used in aircraft construction, including the mechanism of fatigue and fracture, which on results already obtained may lead in practice to increased tenacity of technical materials, and therefore have a general industrial interest.

At the National Physical Laboratory work has been carried out for the Board on alloys for compass correctors, steel for permanent magnets, and specifications for coloured glasses. Considerable experiment has been made with the object of obtaining a standard "white" light, needed for the purposes of the last investigation. This is intended to represent average daylight, daylight itself being too variable in quality as well as quantity to be used for accurate colorimetric work. It is hoped by completing calculations expressing the tints of the empirical Lovibond scale in fundamental units to lead to standardised nomenclature and methods of colour specification. The National Physical Laboratory is also to make investigations on standardising yellow glass for signal lights, a matter of interest both to the Ministry of Transport in connection with railway signals and to the Air Ministry in connection with aircraft navigational lights. Dr. Hartridge, of Cambridge, has already prepared a report on the physiological aspect. At the request of the Air Ministry the Board has also considered questions relating to the improvement of aircraft instruments in conjunction with the National Physical Laboratory and the British Scientific Instruments Research Association, and will assist the Air Ministry in fundamental researches required for further developing particular instruments.

The Board has also made a grant to Dr. P. Kapitza, working under the supervision of Sir Ernest Rutherford, to enable him to continue his work on the production of sudden and very high discharge currents and momentary intense magnetic fields.

Chemistry Co-ordinating Research Board.—The Chemistry Research Board has caused considerable work to be done on formaldehyde. At the Royal Naval Cordite Factory the oxidation of hydrocarbons has been studied, principally with the object of providing a method of manufacturing formaldehyde in this country. The work has proceeded up to the elaboration of a "not very promising" method, which is now being tried on a semi-manufacturing scale, with results that up to now seem unlikely to lead to commercial success. A technique has been evolved by which ozone, formic acid, formaldehyde and hydrogen peroxide can be estimated in the presence of each other, and information interchanged with the Canadian scientific research authorities, who were engaged on similar investigations, has proved of considerable value. In connection with this work the possibility of using coal gas, coke-oven gas and natural gas is being considered, and information has been collected on the natural gas resources of Canada and the United Kingdom. At the Research Department, Woolwich, researches have been made on the production of formaldehyde by other reactions, with results that were either negative or only partially successful. The Government laboratory has obtained promising experimental results in the recovery of formaldehyde after its use in disinfecting wool and hair; but large-scale trial has been deferred for the present, and alternative and cheap disinfecting solutions will be subjected to experiment at the Home Office Anthrax Disinfecting Station at Liverpool, where the formaldehyde process is working.

At the National Physical Laboratory experiments have been continued on luminous radium compounds, with special regard to the variation of the rate of decay of luminosity with radium content, and the possibility of substituting mesothorium for radium. Investigations made for the Board by the Government Chemist and at the Research Department, Woolwich, into the explosion at Oppau of ammonium sulphate-nitrate led to no conclusive result. The Board's Committee on tests for "permitted" explosives have recommended fundamental research supervised by a committee under the control of the Department of Mines. Following on its report it appeared that no satisfactory method is available for testing the sensitiveness of an explosive, and the Board is now contributing to the cost of a general investigation to be carried out at Woolwich Arsenal into the sensitiveness of high explosives, so far as it affects civilian interests.

The Board is contributing to the cost of an investigation by the Admiralty into the effect of impurities on the capacity and working life of accumulators, and the National Physical Laboratory has conducted further tests on accumulators of recent design. Work on the corrosion of aluminium and its alloys continued under the direction of a Committee of the Institute of Metals, has been directed mainly to protecting the metal by forming a skin of oxide. This is found to delay corrosion under ordinary conditions, but to fail under very severe conditions, such as are produced by alternate wetting with sea water and drying. The film of oxide, however, is strongly adsorbent, and the adsorption of certain materials, which are very difficult to remove, had been found to enhance greatly the protective properties of aluminium and some of its alloys.

Engineering Co-ordinating Research Board.—The Engineering Research Board has co-operated in a good deal of work on fatigue of materials, including Professor Hudson Beare's investigation of the fatigue of spiral springs, Professor F. C. Lea's many experiments on fatigue (which will be continued on the fatigue of valve springs and the effect of heat treatment, cold drawing and grain size on resistance of metals and alloys to fatigue), and Professor W. Mason's new method of measuring the hysteresis in Wöhler test pieces (to be followed with the help of further grants by an investigation on the relation between the life of the specimen and the total work spent on it). Professor C. M. Mason has been engaged on determining fundamental elastic constants of metals, and Professor A. Robertson, working on the strength of tubes, has completed the design of his apparatus for measuring stress and strain of steels near yield point.

The electro-deposition of cadmium and other metals on aluminium, in an investigation begun in the hope of protecting aluminium parts in aircraft from corrosion, was found to involve too great an increase in weight for that purpose. For its general interest has been continued under the direction of Professor Desch. The Board is likewise arranging

to deal with difficulties found by the Ordnance Survey in preparing lithographic zinc plates by electro-deposition.

An experimental machine for investigating big-end bearings has been completed by Messrs. Ricardo and Co. and transferred to the National Physical Laboratory for use in a comprehensive investigation.

The Board's work on light alloys has been continued at the National Physical Laboratory with valuable results, and much attention has been given to methods of casting the "Y" alloy developed at the Laboratory. It has been established that the "burning" of aluminium is not due to repeated overheating. The investigation of the ternary alloy aluminium-copper-nickel rich in aluminium has been completed, and work is in progress on the constitution of aluminium-copper-manganese-silicon alloy and on alloys containing calcium.

Other investigations in progress for the Board at the Laboratory include researches into the causes of detonation of explosive mixtures of gases and the cracking of boiler plates.

The Board is to contribute to a research on die-castings by the British Non-Ferrous Metals Research Association, to be supervised by a committee of the Association, on which interested Government departments will be represented, and to be carried out in sections at the Research Department, Woolwich, the National Physical Laboratory and Sheffield University respectively.

Investigations are being made into the best methods of protecting machinery in store from rust, including tests at the National Physical Laboratory of selected rust preventives, and into the production of brass strip ingots on behalf of the British Non-Ferrous Metals Research Association at the Research Department, Woolwich. Arrangements have been made for further research at the National Physical Laboratory into the strength and properties at high temperatures of materials used in engineering construction.

For the Minor Metals Committee the National Physical Laboratory has begun investigations on alloys containing cadmium and beryllium, beginning with the constitution of copper-cadmium alloys. Beryllium has been prepared in a massive form from its ores, and the properties of a nearly pure specimen are being investigated. A commercial sample of titanium has been found to contain only 92·5 per cent. of the metal.

The Springs Committee has formed panels to deal respectively with materials, the design of laminated springs, and the design of spiral springs. For the panel on materials work has been begun at the National Physical Laboratory on a very comprehensive scheme of research. The laminated spring panel is considering replies to questionnaires addressed to spring users, spring makers and chassis makers, and the design of special plant and apparatus. Tests yielding valuable results have been carried out at the National Physical Laboratory on the endurance of laminated springs under repetitions of stress.

(To be continued.)

GERMAN IMPORTS INTO NEW SOUTH WALES.—According to a customs statement, forwarded by H.M. Trade Commissioner at Sydney, the value of imports of German origin into New South Wales during the month of August, was 34,119*l.*, as compared with 24,958*l.* in July and, 38,862*l.* in June. The principal articles imported, according to their value, included upright pianos, 3,797*l.*; musical instruments, 3,171*l.*; fertilisers, 2,591*l.*; cutlery, spoons, and forks, 1,801*l.*; chassis for motor cars, 1,478*l.*; synthetic dyes, 571*l.*

ENGINEERS FOR MOTOR SHIPS.—The Board of Trade Mercantile Marine Department draws attention to the fact that the arrangements made under which "ordinary certificates" would be available on motor ships, lapse on January 1, 1924. As representations have been made that this may cause inconvenience in the case of a foreign-going motor ship, the Board of Trade has arranged for the issue in certain circumstances to engineers holding ordinary certificates, of temporary permits. Such permits will be granted if application be made two weeks before the date required, and will hold good for a period of twelve months' actual sea service. This will enable an engineer to complete the nine months period in motor ships necessary to qualify for a motor endorsement. The examination for such an endorsement will be adjusted to suit the case of engineers with a long experience at sea, and will be largely oral. If at the end of the twelve months' period an engineer has failed to obtain the requisite endorsement the permit will lapse.

INDUSTRIAL NOTES.

MEETINGS have been held during the week, and are continuing at the time of writing, for considering the railwaymen's wages. The same is the case with reference to the miners' wages.

Following upon discussions, the coal tippers and trimmers at the ports of South Wales have decided to resume working the third shift until January 5, and in the meantime the joint conference has resumed its sittings; failing a mutual agreement, the employers will appeal to the Ministry of Labour to appoint a court of inquiry to decide the point.

Speaking last Monday at the fortieth ordinary general meeting of the Blyth Shipbuilding and Dry Docks Company, Limited, the chairman, Sir Walter Runciman, Bart., said the company had suffered severely, not only by the life being knocked out of enterprise, but by the recent boilermakers' strike which prevented any possibility of contracts for new vessels being given or taken, and drove a great deal of repair work to the Continent. It was quite accurate to say that but for the boilermakers' dispute a dividend might have been paid. The grievous thing was that so many poor people were dependent on incomes derived from investments of this kind. This was the first time the company had gone without a dividend.

Writing in *Current Opinion* for the present month, Mr. W. L. Hichens, chairman of Messrs. Cammell Laird and Co., Limited, says that in dealing with the relations between employers and employed it is important to remember that capital and management must be treated fairly as well as labour. There is really in the nature of things no ground for opposition, and, in fact, these factors in industry have a common aim. The greatest hardships in this country fall upon the exporting trades, and in these trades wages have fallen out of all proportion to the decline in other trades. Some branches of industry, such as the railways, are internally protected, and there ought to be some way of equalising the rates of wages. It must be remembered that it is to the common interest of everybody that our trade should be developed and employment found for all who need it. This is not the time for suspicion, recrimination, jealousy, self-seeking. It is the time for united action based on one great common purpose.

Although of retrospective interest only at the present time we may record the fact that Mr. D. A. Bremner, director of the British Engineers' Association, sent the following question to members: "Do you wish this association to support the Prime Minister's policy of protecting our manufacturing industries in the home markets?" At the same time, a number of non-member firms also engaged in engineering and allied industries were asked whether they were in favour of the policy. There were received 1,894 replies, the votes being as follow:—

	Per Cent.
In favour	81·8
Against	15·4
Indefinite	2·7

A correspondent to *The Birmingham Post* gives the following percentages of unemployment at the end of October last:—

	Per Cent.
Coal miners	2·5
Building workers	12·2
Ironworkers	16·0
Cotton workers	17·8
Engineers and Shipbuilders	31·5

He adds that in the last forty years there have been great improvements in machinery and working conditions in the collieries, yet the output of coal per man has gone down, as the following figures per man per shift show:—

	Cwt.
1883	25
1903	23
1913	21
1919, 1920, 1921, 1922	15
1923 to date	17

Since the war, the correspondent further states, the miners, with their short hours, restricted shifts and demands for high wages in return for low output, have lost to the country trade beyond computation. The miners' leaders are pressing for more wages without more output, and are advocating measures calculated further to reduce the very small output per unit of labour.

Belgian iron and steel statistics, says *L'Echo de la Bourse*, continue to be very satisfactory. If the production for 1913 be called 100, the production for September and October will be found to show the following index figures: Coal, 99·4 and 109·4; coke, 120·3 and 126·1; briquettes, 70·9 and 75·6; pig iron, 93·7 and 94·8; steel ingots and castings, 94·5 and 105·1; rolled steel, 105·9 and 124·7; iron bars, 72·9 and 71·3. These figures illustrate the energy displayed by the Belgian firms; they also confirm the fact that their works were not wantonly destroyed to the extent which obtained in the case of those in Northern France, it having suited the Germans to act in this way according to plan.

In our last issue we gave a brief abstract of statements made at a recent shareholders' meeting of the Cargo Fleet Iron Company, pointing out the heavy railway tariffs on home iron ore. A letter in *The Times* of last Monday calls attention to the high railway tariffs for the carriage of home-grown timber. These tariffs, as compared with those ruling on the Continent, and taken from reports by the Royal Agricultural Society dated July, 1905, and March, 1906, are as follow, per ton mile in pence, for 62 miles, or 100 kiloms.: England, 2·5; Belgium, 0·6; France, 0·7; Germany, 0·57. To-day, the letter adds, the same burden remains, but with still higher rates, affecting not only the timber industry, but many others which are closely knit to it. It is not only with these charges that reform is necessary, the letter further states, for any traveller in England who knows anything about the transport of timber cannot but be struck with the wholly inadequate means provided and the antiquated methods pursued. The timber trucks here are of the same pattern as those for carrying coal; they can often be seen loaded with one single tree, or a few planks packed on an incline. Attention is also called in the letter to the preferential rates quoted by the British railway companies for foreign timber.

At their meeting held in New York on November 21 and 22, the National Founders' Association, as reported by *The Iron Age*, expressed themselves as favouring the proposals made by Secretary of Treasury Mellon for a reduction in income taxes, and for letting the railways of the country "work out their resuscitation without further Governmental interference."

A speaker at the same meeting said the Communistic doctrine dated from the day of the Order of the Illuminati organised in Germany in the latter part of last century and was now fostered by present-day activities which were largely directed from Lenin's headquarters in Russia. He mentioned the Workers' Party as one of the instruments by which the Communistic doctrine was being spread throughout the United States. The council of this organisation consisted of twelve men, not half of whom were born in the United States, and several of whom had served prison terms for sedition against the country. Instructions from Lenin were spread through many organisations, some of which were possibly ignorant of the manner in which they were being used for furthering the cause of Communism. There were 611 publications of one kind or another preaching unsafe doctrines. Of these, only seventy-three were in the English language. Working men and the general public were being reached by literature distributed in sundry ways, one source being a publicity bureau maintained in Berlin.

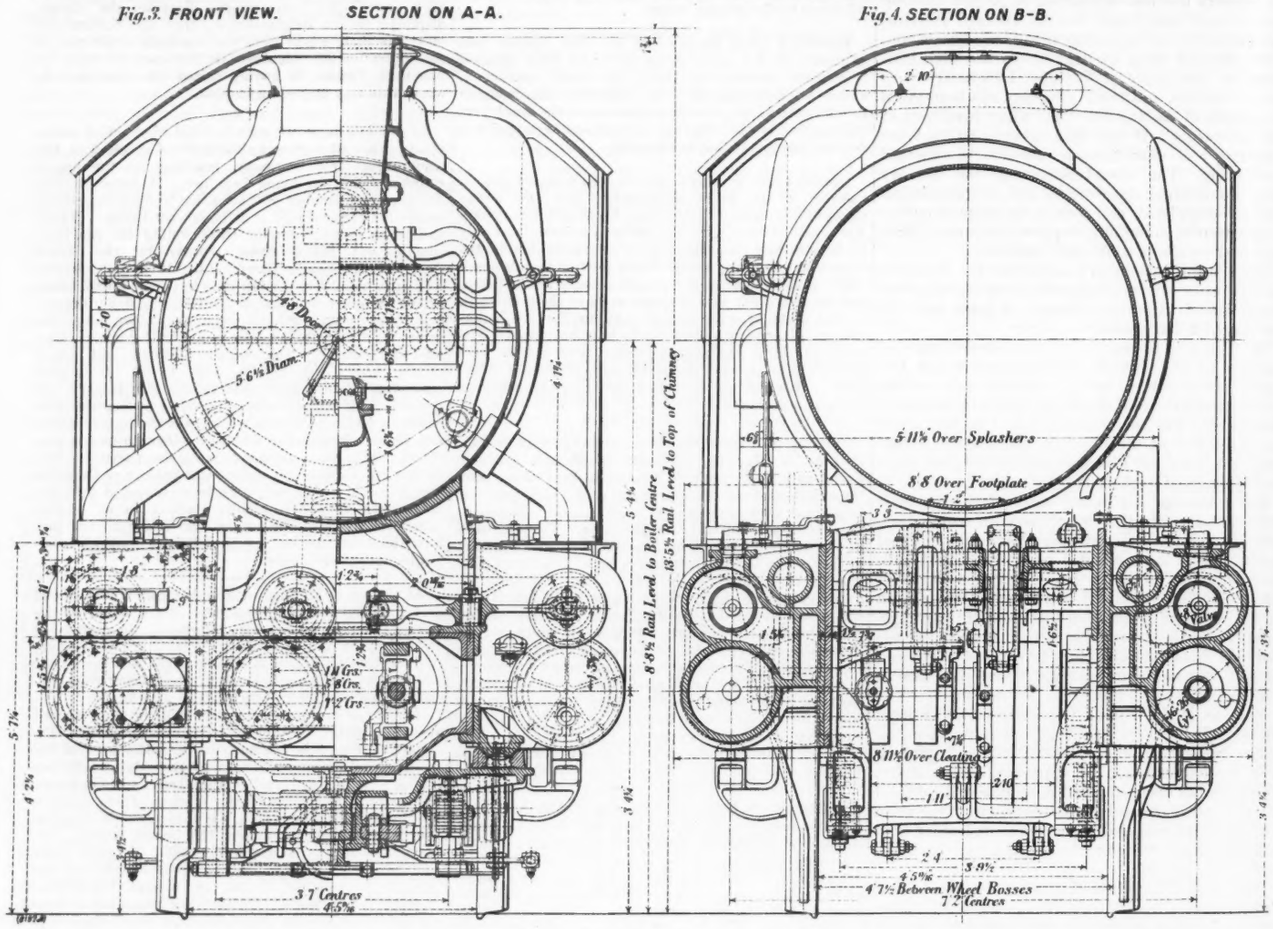
MINE ACCIDENTS.—From a study of the cost and causes of metal mine accidents, made by the Department of the Interior of the United States from data obtained from the records of two large mining companies, it was developed that 48·1 per cent. of injuries occurred during the first two months of employment and that 20·5 per cent. of injuries occurred during the first week. The figures indicate, therefore, that many accidents occur before the miner has become accustomed to the work in the mine in which he has just obtained employment. The records of both companies whose accident statistics were studied show that the majority of accidents occur to the hands, fingers, eyes and toes.

STANDARD TERMS AND DEFINITIONS USED IN RADIO-COMMUNICATON.—Publication No. 166–1923, just issued by the British Engineering Standards Association contains a standard list of about 170 terms and definitions used in connection with radio-communication, and forms one section of a complete list of terms and definitions used in electrical engineering generally, which will be issued shortly. It is not claimed that the list now published contains every term used in radio-communication, but such of the newer terms as survive will be incorporated in future revised editions of the list. In the case of synonymous terms, the one recommended for general use is printed in bold type, and in this way the committee hope to secure a higher degree of uniformity in nomenclature than at present exists. This is, of course, particularly desirable in a rapidly developing science such as that of radio-communication. The list is published at the price of 1*s.* net or 1*s.* 2*d.* post free, and is obtainable through any bookseller from Messrs. Crosby, Lockwood and Son, 7, Stationers' Hall-court, E.C. 4, or direct from the offices of the Association at 28, Victoria-street, Westminster, S.W. 1.

FOUR-CYLINDER 4-6-0-TYPE LOCOMOTIVE; GREAT WESTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S SWINDON WORKS; MR. C. B. COLLETT, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

Fig. 3. FRONT VIEW. *SECTION ON A-A.* *Fig. 4. SECTION ON B-B.*


5' 6½" Diam.
8' 8½" Rail Level to Boiler Centre
13' 5½" Rail Level to Top of Chimney
5' 11⅝" Over Splashers
8' 8" Over Footplate
8' 11½" Over Cleating
3' 7" Centres
4' 7½" Between Wheel Bosses
7' 2" Centres

In our issue of August 24 (page 236 *ante*) we reproduced a photograph and diagram, and gave some particulars of the new 4-6-0 type of express locomotive recently turned out at the Swindon Works of the Great Western Railway. Through the courtesy of Mr. C. B. Collett, M.Inst.C.E., chief mechanical engineer, we are now able to reproduce drawings of this class of engine and in Plate XLII accompanying this issue of Engineering, give in Figs. 1 and 2 respectively an elevation and plan of the machine. Figs. 3 and 4 above, and Figs. 5 and 6 on the opposite page, show cross-sections, &c., taken at the following points: Fig. 3 shows on the left-hand a half front elevation and on the right a half cross-section through the centre line of the chimney looking towards the rear. Fig. 4 is a cross section through the back pair of cylinders, also looking towards the trailing end. The figure next in order, Fig. 5, gives two half-sections, that on the left being taken at C C (Fig. 1) through the leading driving axle, while the one on the right is taken at D D (Fig. 1), *i.e.*, just ahead of the safety valve mounting. Both these look towards the rear. Fig. 6 gives on the left a half-section at E E (Fig. 1) through the fire-box, while the right half of this figure shows a half elevation of the trailing end.

The engine is of the four-cylinder type with two cylinders inside the frames placed well up towards the leading end, driving on to the leading coupled crank axle, and two of similar size (16 in. by 26 in.) outside the frames and driving on to the middle coupled axle. The valves for the latter pair are driven off the motion of the former set by the well-known Great Western arrangement of rocking lever. The piston valves are 8 in. diameter for all cylinders. The inside connecting rods have fork big-ends fitted with gib and cotter. The outside connecting rods have solid bushed big-ends. The frames are 1½ in. thick, joggled at the smoke box. The engine is fitted with a Swindon superheater. The boiler barrel is conical, having a diameter of 5 ft. 1⅛ in. at the front end, which is enlarged to 5 ft. 9 in. at the throat sheet.

In the subjoined table we give further particulars of the engine.

Locomotive:

Cylinders, number	4.
Cylinders, diameter	16 in.
Cylinders, stroke	26 in.
Valves, piston, diameter	8 in.
Wheels, diameter, driving	6 ft. 8½ in.
Wheels, diameter, bogie	3 ft. 2 in.
Boiler barrel, length	14 ft. 10 in.
Boiler barrel diameter, front	5 ft. 1⅛ in.
Boiler barrel, diameter, back	5 ft. 9 in.
Firebox length, outside	10 ft.
Firebox, width outside	4 ft.
Tubes, length	15 ft. 2⅞ in.
Tubes, 2-in., number	201.
Tubes, 5½-in., number	14.
Heating surface tubes	1,885·62 sq. ft.
Heating surface firebox	163·76 sq. ft.
Heating surface, total	2,049·38 sq. ft.
Superheating surface	262·62 sq. ft.
Grate area	30·28 sq. ft
Working pressure	225 lb. per sq. in.
Tractive effort	31,625 lb.
Wheelbase, driving	14 ft. 9 in.
Wheelbase, bogie	7 ft.
Wheelbase, total engine	27 ft. 3 in.
Weight on bogie	21 tons.
Weight on leading coupled axle	19 tons 10 cwt.
Weight on centre coupled axle	19 tons 14 cwt.
Weight on trailing coupled axle	19 tons 13 cwt.
Weight of engine, total	79 tons 17 cwt.

Tender:

Wheel base	15 ft.
Tank capacity	3,500 gallons.
Weight in working order	40 tons.

Locomotive and Tender:

Wheel base, total	54 ft. 6½ in.
Length over buffers	65 ft. 1½ in.
Weight in working order	119 tons 17 cwt.

The engine is fitted with equalised brake rigging, the bogie also being braked.

THE "GRAVITY" FIRE ALARM SYSTEM.

The importance of obtaining the earliest possible warning of an outbreak of fire is now so generally realised that considerable interest is likely to be taken in any improvement in the means by which such warnings may be given. For this reason we propose to describe briefly the system developed by the "Gravity" Automatic Fire-Alarm Syndicate, Electra House, Moorgate, E.C.2, which has recently been demonstrated at the offices of the Institute of Patentees, 44, Great Russell Street, Bloomsbury, W.C.1. It is claimed for this system that it can be installed at about half the cost of a system employing electrical thermostats, is extremely simple, requires no attention, and does not involve the use of batteries. Another point in its favour is that it can easily be protected from the action of corrosive fumes so that it can be installed safely in chemical works, breweries, tanneries and other industrial concerns where fumes and vapours might interfere with the action of other systems.

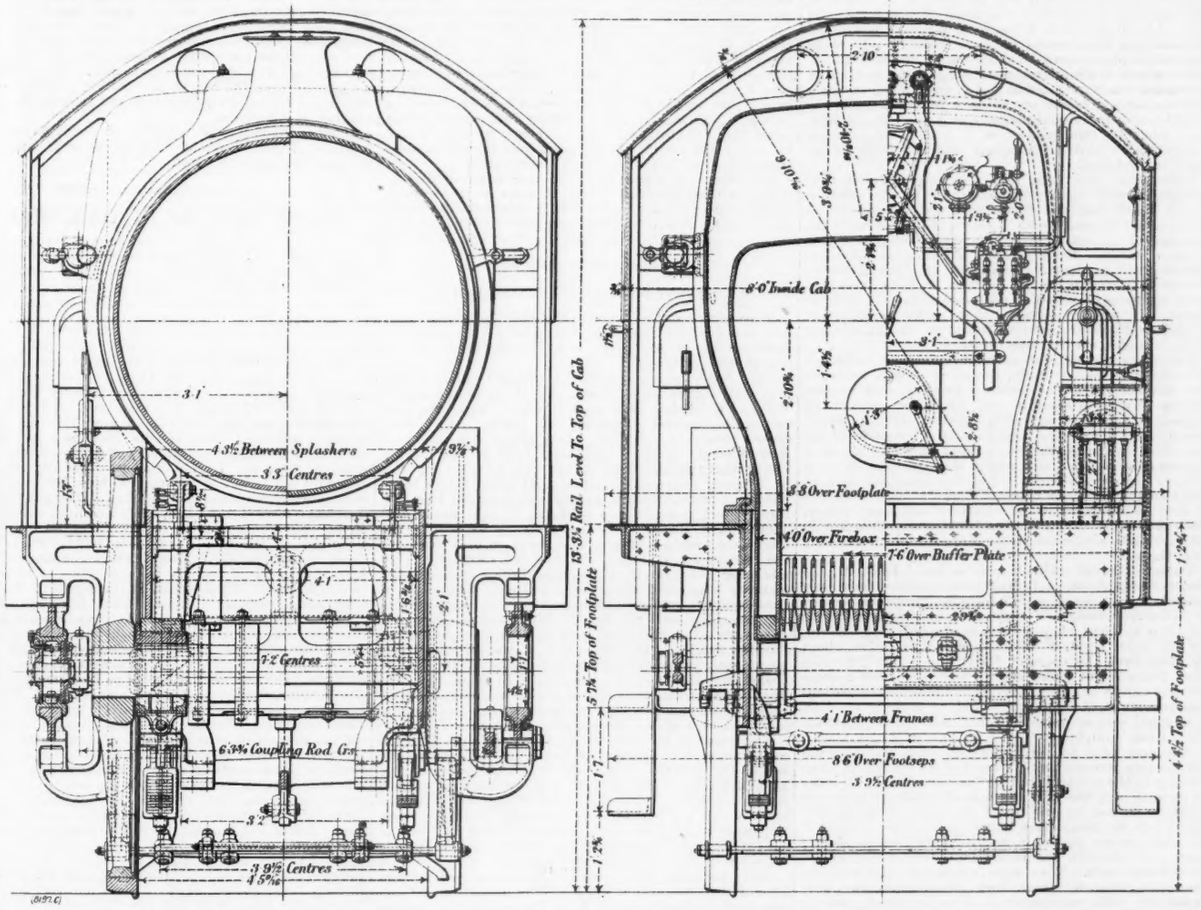
The essential feature of the system is the employment of a thin stranded cable of phosphor-bronze wire which is run along near the ceiling of the room to be protected, supported where necessary by screw eyes and anchored at one end. At the opposite end of the room the cable passes over a small pulley and a weight of 10 lb. or 12 lb. is attached to the end of the cable to keep it taut. At suitable intervals along the length of the cable, usually of about 20 ft., special collapsible rings are inserted, the cable, which is continuous, making two complete turns round the periphery of each ring. The rings are of composite construction, each comprising two brass flanges which serve to keep the turns of the cable in position, a narrow and thin brass cylinder, which supports the compressive stress due to the pull on the cable, and a central ring composed of a fusible alloy, which normally holds the other parts of the ring together. If, however, any one of the rings is subjected to a temperature of about 160 deg. F., the fusible metal melts and the ring falls to pieces, the

FOUR-CYLINDER 4-6-0-TYPE LOCOMOTIVE; GREAT WESTERN RAILWAY.

CONSTRUCTED AT THE COMPANY'S SWINDON WORKS; MR. C. B. COLLETT, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

(*For Description, see opposite Page.*)

Fig. 5. SECTION ON C.C. *SECTION ON D-D.* *Fig. 6. SECTION ON E-E.* *BACK VIEW.*



slack thus produced in the cable, which amounts to 10 in., allowing the weight at the end to fall through this distance. In falling, the weight releases the mechanism of a large weight-actuated gong, which is thus set ringing and continues to ring for about 15 minutes for the purpose of attracting the attention of any person in the vicinity of the building.

The gong is generally placed outside the building, and in the same box with it is mounted a microphone, or transmitter as it is usually called, connected with the Post Office telephone system. When the gong is set ringing by an outbreak of fire, a contact operated by the gong mechanism is made which indicates a call to the exchange in the ordinary way. The operator responding to this call, however, hears the sound of the gong, which is easily recognised as a fire call, and at once connects the call to the fire-brigade station without considering from which subscriber it originated. It is, of course, necessary for the location of the origin of the call to be identified at the fire station, and this is arranged for in a simple and effective manner. In the box containing the gong and transmitter is a contact actuated by a toothed wheel which is rotated continuously by the mechanism of the gong. The contact is arranged to open and close the transmitter circuit in such a manner that the sound of the gong is heard as a series of strokes divided into groups of from one to five, with a short interval between each group. By counting the strokes heard in each group, which might for example consist of four strokes followed by three strokes and then by a longer interval of silence (this sequence indicating the number 43), the operator at the fire station can identify the call by reference to a pre-arranged code. The strokes are, of course, transmitted in the same sequence for the whole of the time that the gong is ringing, and, as no more than five strokes are used to form one group, there is no likelihood of mistakes being made in counting. The advantages of the arrangement, are, obviously, that the current for operating the transmitter is supplied by the central battery of the telephone system, and also that no direct connection from the subscriber to the fire station is necessary. The Postmaster General, we understand, has sanctioned the use of the arrangement described in connection with the Post Office telephones in any part of the country, subject to the approval of the fire brigade authorities concerned.

With regard to the installation in the subscriber's building, we should explain that each cable may have any length up to 500 ft. and one collapsible ring is used to protect an area of 250 sq. ft. Usually one cable would be employed on each floor of the building, and the weights attached to all the cables would be arranged all together in any convenient central position. The weights are enclosed in a casing in which windows are provided so that it can be seen at a glance which weight has fallen, and thus the particular floor on which the fire has occurred can be determined. The fall of any one of the weights sets the gong in operation and transmits the signal to the fire station through the telephone exchange as described. We may here point out that the expansion and contraction of the cable due to ordinary temperature variations from 32 deg. F. to 120 deg. F. only affect its length by about 1 in. for each 100 ft., so that even when the maximum length of 500 ft. of cable is employed the variation of length of 5 in. is only half that due to the collapse of one ring. It should also be mentioned that the system can be readily tested at any time by releasing the anchorages at the ends of the cables and allowing the weights to fall.

In conclusion, we may mention that a modification of the system has been suggested for indicating a dangerous rise of temperature in coal piled in a heap or contained in ships' bunkers, as well as for giving warning of gob-fires in mines. For this purpose, an arrangement functioning on the Bowden principle is employed and this is placed in the coal in a suitable position. The arrangement consists of a cable enclosed in a flexible metallic tube, to the distant end of which the cable is anchored. Collapsible rings, similar to those described above, are inserted in the cable at intervals, the rings being enclosed in metal cylinders connected into the flexible tube at corresponding positions along its length. It will be understood that the cable can be kept taut by a weight suspended from its free end without affecting the flexibility of the tube and irrespective of the disposition of the latter, but that if one of the rings collapses, the weight will fall, and can thus be made to operate any convenient form of alarm signal. At the demonstration of this device we recently attended, the ring collapsed and the alarm was given a few seconds after one of the cylinders had been inserted in a bucket filled with hot water.

THE VALUE OF NAVAL AEROPLANES.

AT a meeting of the Society of Naval Architects and Marine Engineers, held in New York on November 7 and 8, a paper was read by Captain E. S. Land, entitled "Comments on Aviation—Naval and Commercial." To the discussion which followed Professor W. Hovgaard, of the Massachusetts Institute of Technology, contributed some interesting remarks on the use and limitations of aeroplanes in war service connected with fighting, &c., at sea. An abridged report of Professor Hovgaard's remarks is as follows :—

In coast defence it was probably safe to reckon upon an effective range of airplanes up to about 100 miles from shore, more or less according to circumstances. This might sound to many as a too conservative statement, but it must be borne in mind that when extended coast lines, as, for instance, those of the United States, were to be patrolled effectively, a great number of planes would be required, and this number soon became prohibitive when the range was increased. If a belt or lane of some 50 miles to 100 miles could be kept under active

surveillance of planes along the coast at all times it would permit the coastwise trade to be carried on in relative safety and would render a close blockade practically impossible. Enemy sea craft could approach the coast only at great risk. Even if enemy ships were patrolling at a great distance from the coast they would be liable to occasional attack by airplanes, since raids could be carried out to ranges which under favourable circumstances might be as much as 500 miles or more.

Landing of troops in force on an enemy coast could only be carried out with any prospect of success if it were possible to establish command of the air at the point of landing, but in attempting to attain this object the attacking force would be at a great disadvantage because the planes must be carried on board of ships.

It was true of a long continued coastal war, as of other protracted war services, that the number of units was a most important factor on account of the liability to breakdown of individual planes and on account of their short life. In this connection it was of the utmost importance to have an adequate outfit of facilities for repair and renewal.

From what had been said above it followed that passage through Straits such as those at the entrance to the Baltic and the Black Sea, and the Straits of Malacca and Korea, would be rendered dangerous in the presence of an active enemy bordering on the coasts of such waters. Even passage through the Mediterranean could be denied or rendered very precarious to Powers at war with France, or Italy or Spain, provided these countries possessed an adequate number of suitable planes. It was conceivable that under certain war conditions England might be forced to direct the main traffic to India, *via* the Cape route.

The safety of naval stations might be strongly affected, favourably or unfavourably, according to their location. For instance, in a war between England and France, stations like Portsmouth and Cherbourg would be exposed to attack by airplanes, but since they had direct access to all the military and industrial resources of the respective countries, they were both able to put up a vigorous air defence and might thus perhaps enjoy a relative degree of security. For naval stations such as those on the mainland of the United States, the advent of aircraft was a source of additional defensive power, since an enemy would always be at a disadvantage in attempting to secure command of the air when attacking from the sea.

Detached naval stations such as Pearl Harbour, the Canal Zone, Aden and Singapore, distant from any possible enemy base, would likewise gain considerably in defensive strength if they were well equipped with airplanes and had adequate means of repair and renewal. On the other hand, a station situated as Malta, about 60 miles from the coast of Italy, and about 160 miles from Tunis might under certain war conditions become entirely unsafe as a port of refuge. Likewise the harbour and roadstead of Gibraltar would be entirely insecure if England were at war with Spain, however impregnable the "Rock" might be.

Airplanes, due to their short effective radius could not operate independently over the sea except in close vicinity to the coast where they had their base. In order to operate over the wide expanse of the ocean airplanes must be carried by and based on ships. Such carriers could not by themselves secure permanent control of the ocean or any part of it, nor could they independently carry out offensive operations across the ocean, except in isolated raids. They were vulnerable and required protection against attack from other ships, and such protection could only be obtained by means of powerful artillery ships. Thus we arrived at the capital ship as an indispensable type, but it might come to differ in certain characteristics from the present battleship or battle cruiser and might even come to combine the functions of an airplane carrier with those of the artillery ship. As hitherto, it must be associated with cruisers, destroyers and various other craft, and thus the airplane carrier, of whatever type, became a member of the complex organism which constituted a fleet. While the airplane carrier obtained protection from the fleet, it added to its strength.

If a fleet were adequately provided with planes of the various types—for observation, spotting, fighting or pursuit, bombing, and torpedoing—it could extend the area of reconnoitring and the heavy artillery could be used at greater ranges. If the air force of a fleet succeeded in securing command of the air, it could attack the ships of the enemy fleet with bombing and torpedo planes, and might then inflict enormous damage. It was seen that the presence of airplanes would cause fleet actions on the whole to take place at much greater ranges than hitherto, and they would also in other ways exert an important influence on tactics, but it appeared that strategic conditions on the ocean would remain essentially unaltered.

The *rôle* of the aeroplane in a fleet was not unlike that of the destroyer. There would be actions between planes, just as there were actions between destroyers at the battle of Jutland, and it was likely that there would be great losses. The airplane, being very dependent on weather conditions, would be—still more than the destroyer—a weapon of opportunity. It soon expended its force and its means of attack, and was in that respect analogous to a projectile. The carrier formed a precarious base for the air planes, and might be destroyed at any time. Under these conditions it was difficult to see how the airplane could come to dominate the situation in fleet actions, although they might well under certain circumstances exert a profound influence on the course and the issue of the battle.

Airplanes, in the present stage of development, and as applied in naval warfare appeared to have their greatest and most certain value as a means of coastal defence, although on many occasions, especially in actions between ships, they might achieve great results when used offensively.

The advent of aircraft was of special benefit to the United States, since that country with a well-developed coastal air defence and a strong navy could be made practically impregnable in virtue of its insular position. It was of particular importance in the defence of Hawaii and the Canal Zone, provided these stations were given not only an initially strong air force, but also an adequate equipment for repair and new construction of planes. If the latter condition were not fulfilled, the air force might be exhausted before reinforcements could arrive.

Aircraft would also be of great benefit to the British Empire in the defence of its vast and scattered parts, many of which had an insular or quasi-insular position remote from the base of possible aggressors (Australia, New Zealand, South Africa, &c.). As regards England, herself, the insular position was again an advantage in a defensive warfare, but the immunity from attack which could formerly be obtained by supremacy at sea, was lost for ever. The security of the naval stations was in some cases improved, in others greatly depreciated.

All references made above to war between certain countries were intended merely to serve as illustrations of the change caused by aircraft in the strategical conditions and had no connection whatever with the political relations actually existing between these countries.

SOCIETY OF GLASS TECHNOLOGY.

A meeting of the Society of Glass Technology was held in Leeds, on Wednesday, November 21, the president, Professor W. E. S. Turner, D.Sc., in the chair. Three papers were presented :—

(*a*) "*Notes on the Influence of Rapid Chilling on the Reversible Expansion of Clay*," by H. S. Houldsworth, M.Sc. The author gave some results of measuring the reversible thermal expansion of fireclay test pieces cooled slowly and rapidly. Test pieces were moulded from Farnley fireclay, dried and fired in the surface combustion laboratory furnace to cone 9 (1,280 deg. C.), in 3 hours, and maintained at that temperature for a further 2 hours. One test-piece was removed from the furnace and plunged into a bucket of cold water, and another was placed on a steel plate to air-cool in the laboratory, while a third was allowed to cool slowly in the furnace for 17 hours. A glass pot mixture of clay and grog obtained from the Stourbridge district in a leathery condition was next examined. There was a considerably greater difference in the temperature-expansion curves of the rapidly chilled and slowly-cooled specimens after firing at cone 9, than was found for Farnley fireclay. The expansion of the air-cooled test pieces was intermediate between those of the water-cooled and slowly-cooled samples. At cone 14 (1,410 deg.) the thermal expansion of the air-cooled and water-cooled specimens were nearly the same, and considerably less than that of the slowly-cooled test pieces.

The whole of the phenomena were consistent with the explanation that solution of free silica occurred at the higher temperature of heating, that this separated out as cristobalite or tridymite on slow cooling, and exerted its characteristic influence on the expansion curve, but that it did not so separate on rapid cooling. Some imperfect separation was, perhaps, likely, but not in a sufficiently definite form as to be able to exert its proper influence on the expansion phenomena.

(*b*) A paper by Mr. Percival Marson, entitled "*Glasshouse Pots. Some Notes on their Manufacture and Use*," was read by Professor W. E. S. Turner, in the absence of Mr. Marson. After suitable weathering the fireclays used as pot clays were ready for blending, mixing and grinding. Part of the new mined lumps of fireclay were selected and sent to the kilns for burning. When burnt, these lumps were broken up, inspected and ground down for the grog used in the pot-clay mixtures. The preparation and nature of this grog and the proportion used in the mixture was of great importance. It should not be burnt to less than 1,350 deg. C., and should be free from the faults of burning, such as black core and soft firing. The grinding and grading should also be kept within prescribed standards. The author recommended a grade not coarser than 10 mesh for pot-clay grog, giving a residue of not more than 35 per cent. on a 16-mesh screen. For the blend he recommended a mixture of not less than 25 per cent. grog to 75 per cent. clay as the most suitable for general purposes. A few simple works tests were then made, and the dry clay, if satisfactory, put into large glazed brick tanks with about 25 per cent. of water, and allowed to sour for a period before tempering up the batch. The clay, after maturing in soak for a month, was trodden ready for use. The methods of pot manufacture were next noted, the author observing that pots which had been stored for two or three years after drying gave more regular and reliable results than new pots used shortly after drying. Reference was then made to the different practices in vogue in heating up pots in the pot arch. It was recommended that no shorter time than nine days be occupied in bringing up large pots in the arch. Unless pyrometric control were available any shorter period was not advisable.

Attention was next directed to the most important happening in connection with the life history of pots, "pot setting," or the transference of the pot from the pot arch to the furnace. After setting, the pot should be left to mature in the furnace for not less than 48 hours before opening or filling on. Mention was also made of the chief faults which pots developed in the drying room, pot arch and furnace.

(*c*) "*The Casting Process for Glasshouse Refractories in German Glass Plants*," by Professor Kurd Endell, Dr.Phil., of the Technische Hochschule, Charlottenburg, Berlin. Professor Endell considered that the casting process would give satisfactory results in practice. Success depended upon careful and trained supervision, as well as on the proper selection and preliminary treatment of the clay. When the articles were required for internal use, or when only certain standard sizes of pots or blocks were to be made, manufacture by the casting process was undoubtedly more economical than by hand. All tests hitherto made for comparing the quality of cast goods with that of hand-made goods showed that cast pots were denser than hand-made ones. He was unable to present any precise experimental results on chemical resistance to molten glass, but he believed that cast pots were chemically more resistent than hand-made pots. Tests both with Seger cones and under load showed no perceptible difference in heat resistance between cast pots and hand-made pots. He confidently anticipated that the use of the casting process for the shaping of refractory materials would gain an increasing number of adherents.

During the forenoon a party of members had the privilege of visiting the Wortley Works of Messrs. Leeds Fireclay Company, Limited

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The suspension of several big contracts for steel supplies and engineering products is attributed to dislocation arising from the General Election, but so far as forward business is concerned a more hopeful tone characterises the market, and there are prospects of more active conditions in the New Year. Iron and steel output is steadily expanding. Steel-makers have placed orders for increased tonnages with producers of hematites, and there is also a bigger call on local furnaces for forge and foundry iron. The upward trend of prices is maintained, and while the immediate effect has been to spur users into the market to cover increased commitments, there is a real danger of values reaching a level which may sprag revival in the finished sections. During the past month advances ranging from 1*s.* 6*d.* to 15*s.* per ton have been registered in official quotations of iron and steel. The most notable instance is that of soft basic billets which have risen from 8*l.* 5*s.* delivered at works, to 9*l.* Other revised quotations are as follow :—Hard basic billets, 10*l.*; West Coast hematites, 6*l.*; East Coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry iron, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bars, 12*l.* 10*s.*; sheets, 15*l.* Prospects at the bar mills have improved considerably on wagon building account. Special steels are rather more active, with increased inquiries from users in countries where tariff barriers represent a big obstacle. Several nice orders have been received from South America, France and the United States. The light foundries are delivering increased tonnages to the building trades. Further orders are expected locally any day in connection with British transport undertakings. Conditions in the lighter sections are exceptionally mixed. Some of the tool trades supplying automobile engineers are working at full capacity, but the majority of plants producing engineering requisites are engaged only from three to four days a week. File output shows a steady rise. A Sheffield firm has booked an Admiralty contract for 13,000 dozen. Inquiries are in circulation from Australia and South Africa, though American competition is still very keen. Hardware is on order from the British West Indies, South Africa and the Argentine. Continental business is still very disappointing, though France continues to place orders in Sheffield for steel of guaranteed quality, mainly for automobile construction.

South Yorkshire Coal Trade.—Price advances are general with the exception of slacks and smalls, though both are in good request, and are firmly held at current rates. Best steam hards have appreciated 9*d.* per ton under the influence of a more active demand on home account, supported by big Continental sales. Cobbles and nuts, which are leaving the collieries much more freely, show advances ranging from 1*s.* to 3*s.* Depots are getting into arrears with supplies of best house coal. Quotations :—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 27*s.* 6*d.* to 29*s.*; Derbyshire best brights, 27*s.* to 29*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 22*s.* to 23*s.* 6*d.*; Derbyshire best small nuts, 17*s.* 6*d.* to 19*s.* 6*d.*; Yorkshire hards, 22*s.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

Japanese Naval Construction.—We understand that the two light cruisers Isudzu and Yubari and destroyers numbered 3, 5 and 18, have recently been completed for the Japanese Navy. The Isudzu is a vessel of 500 ft. in length and displaces 5,570 tons with a draught of 16 ft. Her machinery develops 90,000 h.p. and gives the vessel a speed of 33 knots. The armament consists of seven 5·5-in. guns and two 12-pounder anti-aircraft guns, while four double 21-in. torpedo tubes are also provided. The Yubari is a smaller vessel displacing 3,100 tons, her length being 435 ft. and her draught 12 ft. We cannot state the horse-power of the machinery in this case, but the designed speed of the vessel is 32 knots and her armament includes six 5·5-in. guns and four 21-in. torpedo tubes. The destroyers numbered 3 and 5 are identical, each being 320 ft. in length and displacing 1,400 tons on a 10-ft. draught. These vessels attain a speed of 34 knots with 38,500 h.p. and carry four 4·7-in. guns as well as three double 21-in. torpedo tubes. Destroyer number 18 is of 900 tons displacement, her length being 275 ft., her draught 8 ft. 4 in., and her speed 31·5 knots. She carries three 4·7 in. guns and four 21-in. torpedo tubes.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron is in only moderate request, but the falling-off in buying is believed to be the usual lull before Christmas when consumers take as small supplies as possible just before stock-taking. Home demand is expected to expand, but there seems little promise of improvement in export trade. Some good home sales over periods next year have been arranged. No. 1 is 107*s.* 6*d.*; No. 3 g.m.b., 100*s.*; No. 4 foundry, 97*s.* 6*d.*; and No. 4 forge, 96*s.* 6*d.*; all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—Output of East Coast hematite is being increased by the re-starting of two blast-furnaces at the Thornaby Works of Messrs. Whitwell and Co., but notwithstanding enlargement of production values continue to move upward. In this branch also demand is almost entirely for home use. Nos. 1, 2 and 3 are now 102*s.* 6*d.* for early delivery, and No. 1 is put at 103*s.* 6*d.*

Foreign Ore.—There is a firmer feeling in foreign ore. A few inquiries in the market, however, do not result in much actual business. Best Mediterranean ores are 23*s.* 6*d.* c.i.f. Tees, and best rubio is put at 25*s.*

Coke.—Durham blast-furnace coke is distinctly easier. Good medium qualities are quoted 37*s.* 6*d.* to 38*s.* 6*d.* delivered to local consumers' works.

Manufactured Iron and Steel.—Finished iron and steel producers are much better placed than for a long time past. Most firms have now quite a lot of work on hand, and for nearly all descriptions of material inquiry is expanding. Specifications for shipbuilding requisites are being given out rather freely. Plates and angles, as well as joists, have moved up 10*s.* Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.* 10*s.*; fish plates, 13*l.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 19*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Now that the political turmoil is over and we know where we stand on the all-important question of Protection *versus* Free Trade, there is a possibility of business settling down a bit. But the result of the elections has perhaps only tended to increase the unsettled state of men's minds because of the fact that we may require to go through the whole thing again before long and business will once more be upset. In the Scottish steel trade there has been little doing this week and the chief item of note is an advance made in prices as from Friday last. This decision was agreed to at a meeting of the Scottish steel makers held in Glasgow last Thursday. The new minimum basis quotations agreed to were:—Ship plates, $\frac{3}{16}$ in. and up, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; angle, beams and joists, 10*l.* per ton, with the usual extras. Boiler plates are still quoted at 13*l.* per ton, and all are delivered Glasgow stations. There is not a very large amount of work on hand, but the improvement which lately became noticeable is being fairly well maintained, and producers are hopeful of securing an increased number of contracts to ensure better running after the New Year holidays. There is no change in the position at the black sheet mills, and outputs are quite good. Prices have firmed up, and at a meeting of the Scottish Steel Sheet Makers' Association held in Glasgow yesterday (Tuesday), the following new rates were fixed:—Black sheets under $\frac{1}{4}$ in. to $\frac{3}{16}$ in., 12*l.* per ton; under $\frac{3}{16}$ in. to $\frac{1}{8}$ in., 12*l.* 10*s.* per ton. Other gauges were not altered in price.

Malleable Iron Trade.—The West of Scotland malleable iron trade continues to improve, and there is rather more doing all round. Buyers have been more in evidence of late, and not only is bar iron in better demand, but re-rolled steel is also moving more satisfactorily. Prices are firm, with "Crown" bars called 12*l.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—The improved conditions in the Scottish pig-iron trade, referred to last week, are well sustained and quite a good forward tonnage has been booked. Better deliveries of hematite are being made to the steel works, and consumers of foundry grades are also booking supplies a little more freely. Overall there is a much better tone prevailing, both on home and export account. Prices continue very firm and the following are to-day's quotations:—Hematite, 5*l.* 8*s.* 9*d.* per ton delivered at the steel works; foundry iron, No. 1, 5*l.* 11*s.* 3*d.* per ton, and No. 3, 5*l.* 6*s.* 3*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, December 8, only amounted to 824 tons. Of that total the overseas ports accounted for 682 tons and the balance of 142 tons went coastwise. For the corresponding week of last year the figures were 1,624 tons foreign and 140 tons coastwise, making a total shipment of 1,764 tons.

Clyde Shipbuilding.—An order for a vessel of 8,000 tons deadweight has been secured by Messrs. Archibald McWilliam and Sons, Limited, Dumbarton. This vessel will propelled by single-screw Diesel machinery.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Arrangements have been made to resume third shift working by the coal trimmers and tippers at Cardiff, Penarth and Barry, to-night until January 5 next, when failing an agreement between representatives of the employers and the men the third shift will be discontinued at all the South Wales ports. On December 4 last, when the six months' experimental period ended, the coal tippers at Cardiff, Penarth and Barry declined to continue night work and the trimmers were automatically obliged to cease working by night. Efforts were made to get the men to resume work pending a joint conference without success, for on two occasions they rejected the advice of their leaders to resume. Eventually the Great Western Railway—the employers of the tippers—informed the 100 extra tippers taken on for the working of the third shift that unless they resumed night work their services would be dispensed with from to-morrow. On Monday a special conference of the employers and men was held to consider the matter, and the men's representatives unanimously decided to recommend the men to return to work until January 5 next. This recommendation was placed before the men at separate meetings and accepted, though the Barry trimmers asked that the matter should be considered at a mass meeting on Sunday next. As a result the third shift will be resumed to-night, and it is hoped will be the means of relieving the congestion now prevalent at the docks, for to-day there were no fewer than 78 steamers waiting for loading berths, of which 30 were at Barry, 25 at Cardiff, and 12 at Swansea. This is the largest number of waiting steamers since the introduction of night work in June last. Meanwhile the coal market is strong, and buyers are experiencing difficulty in securing their requirements, so well are collieries sold. Here and there it is, however, possible for buyers, able to take immediate delivery, to secure small concessions from salesmen needing an immediate clearance of wagons delayed by various causes. Best Admiralty large coal is steady at 29*s.* 6*d.* to 30*s.*, with seconds round 29*s.*, and the leading Monmouthshires from 27*s.* to 29*s.* Smalls of all descriptions are exceedingly scarce, and the best bunker sorts command from 21*s.* 6*d.* to 22*s.*, with ordinaries from 19*s.* to 20*s.* and inferiors from 16*s.* Exports of coal as cargo from South Wales in November amounted to 2,382,600 tons, compared with 2,604,600 tons in October. Of last month's total, 1,464,900 tons were shipped from Cardiff, 388,800 tons from Newport, 287,500 tons from Swansea, 216,300 tons from Port Talbot, and 25,000 tons from Llanelly. Exports to France amounted to 1,042,700 tons; Italy, 355,400 tons; South America, 215,800 tons; Spain, 95,100 tons; Portugal, 56,900 tons; Greece, 33,300 tons; British coaling depots, 174,500 tons; United States of America, 17,200 tons; Canada, 13,100 tons; Belgium, 112,100 tons; Holland, 58,300 tons; Germany, 46,300 tons; Irish Free State, 45,900 tons; and other countries, 115,800 tons.

Iron and Steel.—Exports of iron and steel goods last week amounted to 17,000 tons, or 2,100 tons less than in the previous week. Shipments of tin and terne plates totalled 6,400 tons, compared with 11,900 tons; black plates and sheets to 6,200 tons, against 5,900 tons; galvanised sheets to 1,500 tons, against 1,200 tons; and other iron and steel goods to 2,900 tons, against 150 tons.

AUTOMATIC ELECTRIC MOTOR STARTING GEAR.—Our apologies are due for the fact that among the illustrations accompanying our description which appeared on page 713 *ante* of the Automatic Electric Motor Starting Gear, constructed by the Watford Electric and Manufacturing Company, Limited, of Watford, one block was printed inverted. The illustration we refer to is Fig. 2 appearing on page 716, showing an A.C. panel for three-phase motors. The effect of the lighting is sufficiently obvious, we trust, to have prevented any serious confusion in the minds of our readers.

CONCRETE AND FERRO-CONCRETE IN GERMANY.—The German Beton Verein, the twenty-fifth anniversary of the foundation of which occurred in the first December week, owes much of its development to its early union with the ferro-concrete committee. It was this latter body which enabled the concrete makers to pursue systematic concrete research on the large scale which technical success demanded. Rules and standard specifications for constructions in concrete and ferro-concrete were first issued in 1904; accident statistics were compiled, literature articles published every fortnight, arbitration courts were established, and special branches were founded to deal with sound and economical problems. Dr. Inz. W. Petry had prepared a volume on the aims and history of the Verein for the anniversary.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—Fourteen Entrance Scholarships and Exhibitions are available for award to students entering University College, London, in October, 1924. Three of them are tenable in any of the five College Faculties: Arts, Laws, Science, Engineering, Medical Sciences, or in the School of Architecture. Two of them are tenable in the Faculty of Arts only, one in the Faculty of Science, one in the Faculty of Engineering, one in the Faculty of Laws, three in the Faculty of Medical Sciences, two in the School of Architecture, and one in the School of Librarianship. Most of the scholarships and exhibitions are of the value of £40 a year for three years, but the value of any scholarship or exhibition may be increased by the grant of a supplementary bursary if the circumstances of the scholar or exhibition make such a grant necessary.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 14, at 6 p.m., "Exhaust-Valve and Cylinder-Head Temperatures in High-Speed Petrol Engines," by Professor A. H. Gibson, D.Sc., Member, and H. Wright Baker, M.Sc. Graduates' Section, London: Monday, December 17, 1923, at 7 p.m., "The Management of a Sand and Flint Quarry," by Mr. F. E. A. Manning, Student, of London. Chairman, Mr. E. W. Monkhouse, Member.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, December 14, at 7.30 p.m., at the Royal Society of Arts, St. John-street, Adelphi, W.C. 2. Lecture by Mr. John Gray, B.Sc., M.I.E.E. "Leader Cable Systems for Electrical Steering of Aeroplanes," written by Mr. William Loth, of Paris.

THE INSTITUTE OF METALS; SHEFFIELD LOCAL SECTION.—Friday, December 14, at 7.30 p.m., in the Non-Ferrous Lecture Room of the University, St. George's-square. Paper on "The Metallurgical Microscope—Some Notes on its Construction and Use," by Mr. J. H. G. Monypenny.

THE INSTITUTE OF METALS; SWANSEA LOCAL SECTION.—Friday, December 14, at 7.15 p.m., in the Metallurgical Department, University College, Singleton Park. Paper on "Some Applications of the Brinell Hardness Test," by Mr. A. L. Norbury, M.Sc.

ROYAL SOCIETY OF ARTS, DOMINIONS AND COLONIES SECTION.—Monday December 17, 1923, at 4.30 p.m. "Empire Settlement," by Mr. William C. Noxon, Agent-General for Ontario. The Right Hon. the Earl of Airlie, M.C., will preside.

THE INSTITUTION OF CIVIL ENGINEERS, NEWCASTLE-UPON-TYNE ASSOCIATION.—Monday, December 17, at 7.30 p.m. at the Lecture Theatre, Neville Hall, Newcastle-upon-Tyne. Paper by Mr. B. P. Fletcher, Assoc.M.Inst.C.E., on "Home Railways, the Maintenance of Ways and Works."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 18, at 6 p.m. Paper to be further discussed, "The Bio-Aeration of Sewage," by Mr. Arthur John Martin, M.Inst.C.E. Students' meeting, Wednesday, December 19, at 6 p.m. The second Vernon-Harcourt lecture on "River Training and Maintenance Works," by Mr. Ralph Frederick Hindmarsh, M.Inst.C.E. Members of all classes are invited to attend this lecture.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Wednesday, December 19, at 7.30 p.m., at the Engineers' Club, Coventry-street, W. 1. Paper on "Electric Furnaces," by Mr. L. W. Wild, M.I.E.E.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 19, at 5 p.m., at 49, Cromwell-road, South Kensington. The following papers will be read: (1) "A Note on the Vertical Visibility (estimated Looking Downwards) at Cranwell, Lincolnshire, during the period February, 1922, to June, 1923." by Mr. W. H. Pick, B.Sc., and Mr. S. P. Peters; (2) "The Cause of Cyclones," by Mr. Harold Jeffreys, M.A., D.Sc.; (3) "The Relation of the Circulation in the Upper Air to a Circumpolar Vortex." by Mr. A. W. Lee, M.Sc., A.Inst.P.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON).—Thursday, December 20, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1, "Notes on Locomotive Running Trials," by Mr. E. A. Phillipson, Associate Member.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, December 20, at 7.30 p.m., at Denison House, 296, Vauxhall Bridge-road. Paper by Mr. J. B. Clarke (Member), entitled "Practical Designing of Structural Steelwork, Beam Connections and Clarke's Loading."

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 20, at 5.30 p.m., at the rooms of the Geological Society, Burlington House, Piccadilly, London the following papers will be submitted for discussion: "Ventilation Problems at Champion Reef Mine," by C. F. Heathcote, member. "Notes on the Geology and Ore Occurrences of the Porcupine Gold Field," by Rowland C. Feilding, member.

THE NORTHAMPTON POLYTECHNIC INSTITUTE.—The prizes and certificates gained by the students attending the day and evening courses held at this institution during the 1922–23 session were presented by Sir W. Martin Conway on Friday last, the 7th instant. Twenty-one students secured the B.Sc. (Engineering) degree of the London University during the session, two gaining first-class honours and seven second-class honours, while twenty-one others passed the intermediate examination for that degree. A large number of students were awarded certificates in technological subjects by the City and Guilds of London Institute, and a further number received full-course and class certificates from the Governing Body of the Northampton Institute. These courses cover civil and mechanical engineering and metal trades, electrical engineering and applied physics, optical engineering and applied optics, technical chemistry, horology, &c. The laboratories and workshops were opened for the inspection of the visitors on the occasion of the prize distribution, and also on the following evening on which the annual conversazione for members and students was held. The Institute is situated in St. John-street, Clerkenwell, E.C.1, and full particulars of the various courses and classes can be obtained on application.

THE SUORVA LAKES DAMS, LAPLAND.

(*For Description, see Page* 731.)

FIG. 27. THE WESTERN CHANNEL WITH DAM UNDER CONSTRUCTION.

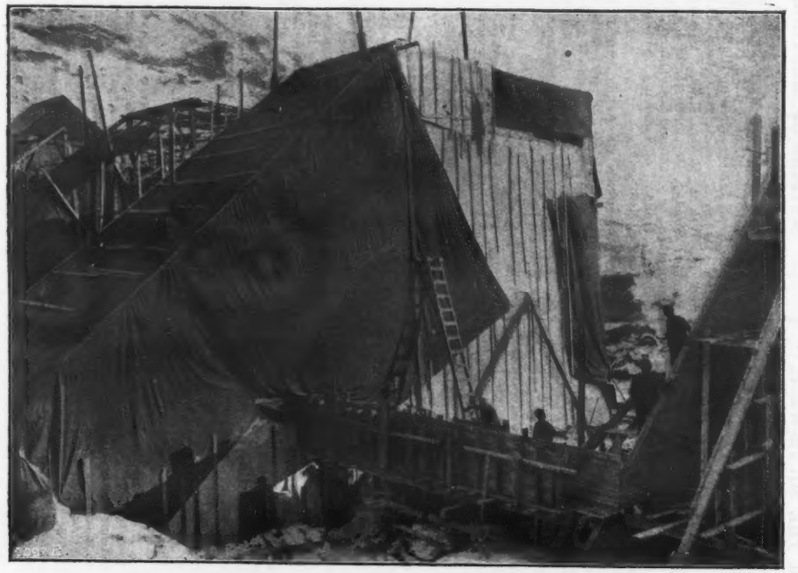


FIG. 28. WORK IN PROGRESS ON BUTTRESSES.

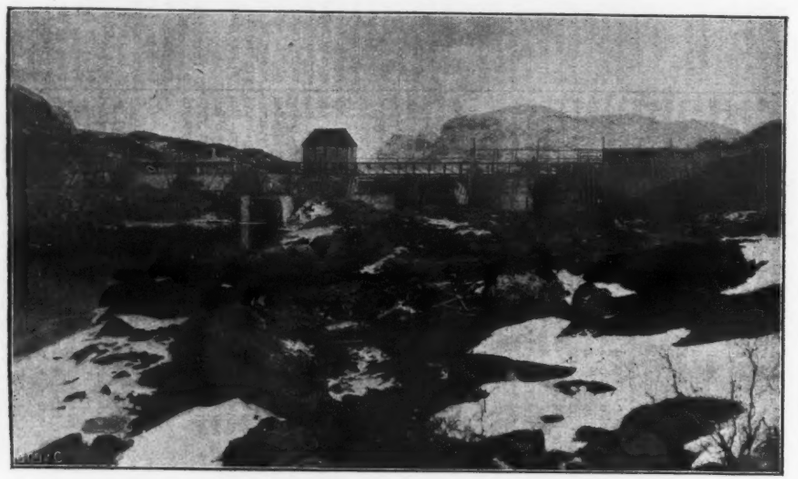


FIG. 29. EASTERN DAM UNDER CONSTRUCTION.

FIG. 30. THE DAM ACROSS THE WESTERN CHANNEL.

Fig. 29. Eastern Dam under Construction.

Fig. 30. The Dam Across the Western Channel.

FOUR CYLINDER 4-6-0-TYPE SUPERHEATER LOTIV

CONSTRUCTED AT THE COMPANY'S SWINDON WORKS TO THE DE[illegible]R. C.

(For Des[illegible]g 742.)

Fig. 1.

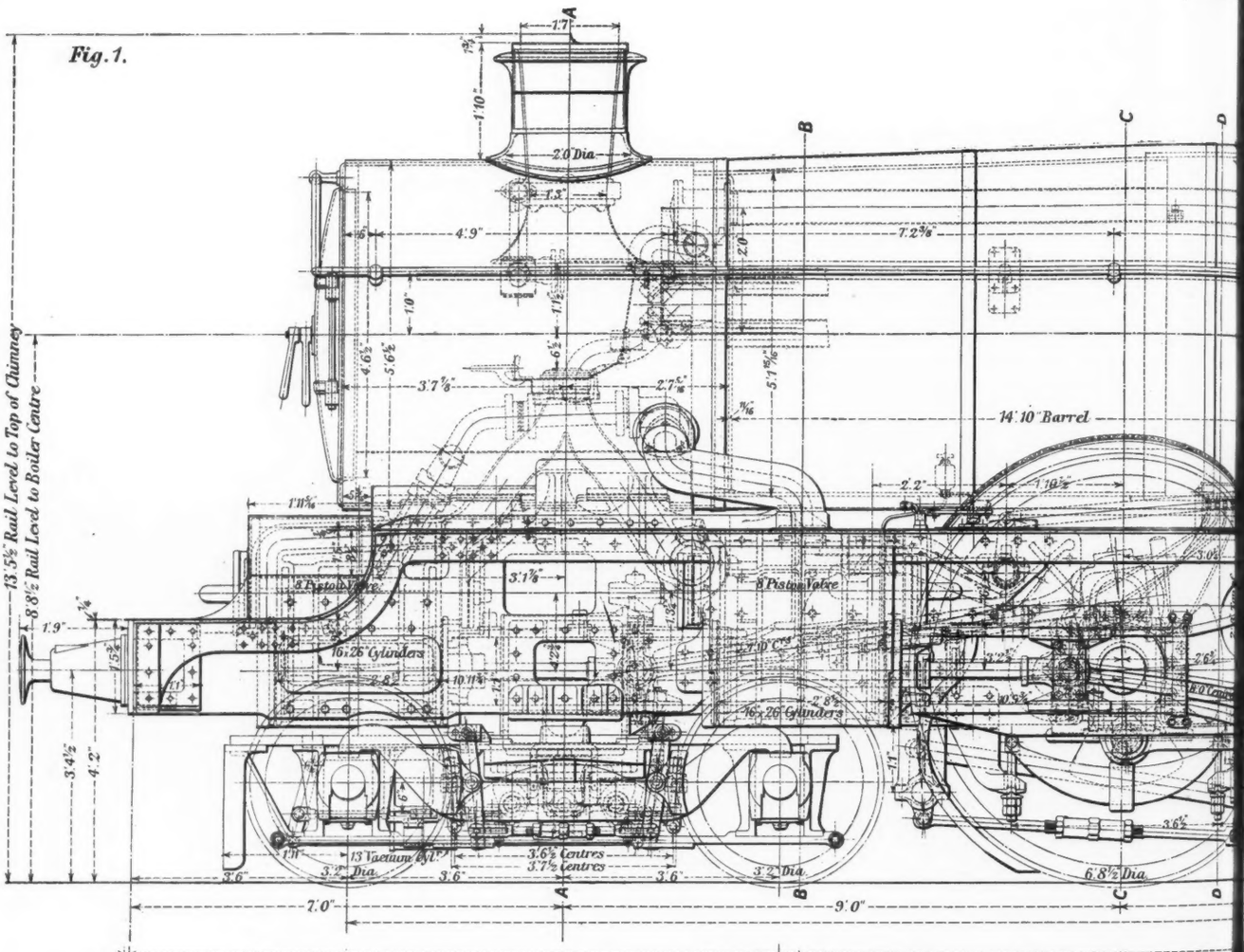
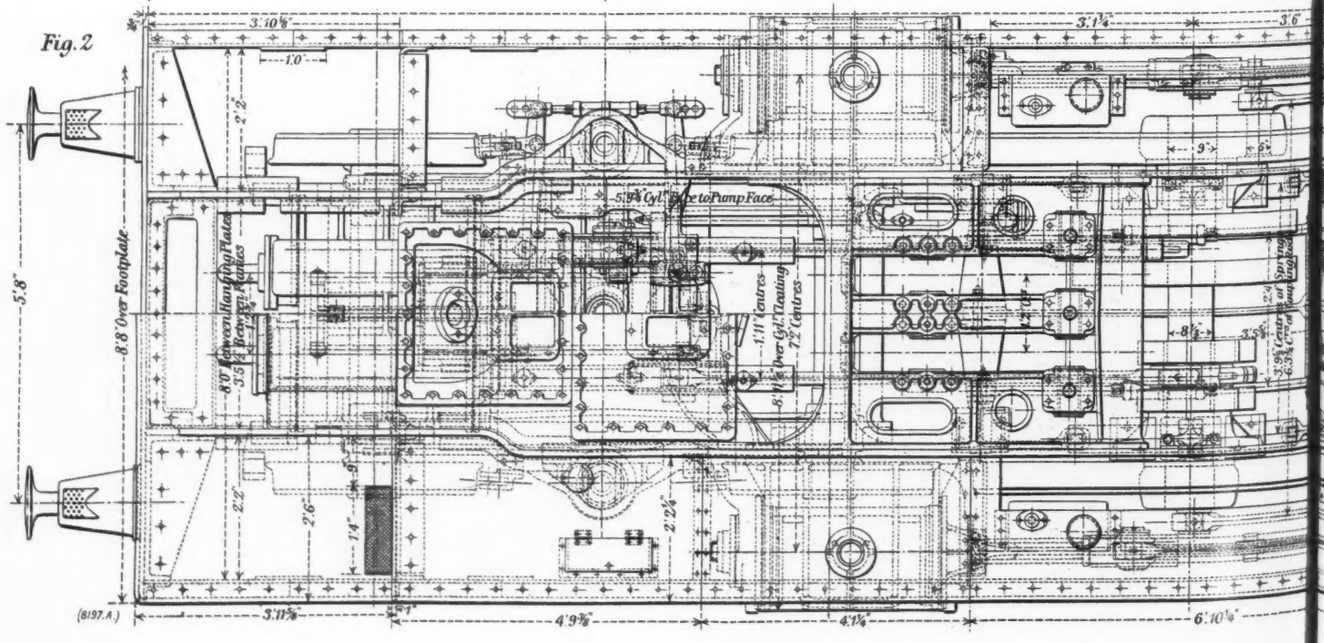


Fig. 2



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ER LOTIVE FOR THE GREAT WESTERN RAILWAY.

D THE DE[illegible]R. C. B. COLLETT, M.INST.C.E., CHIEF MECHANICAL ENGINEER.

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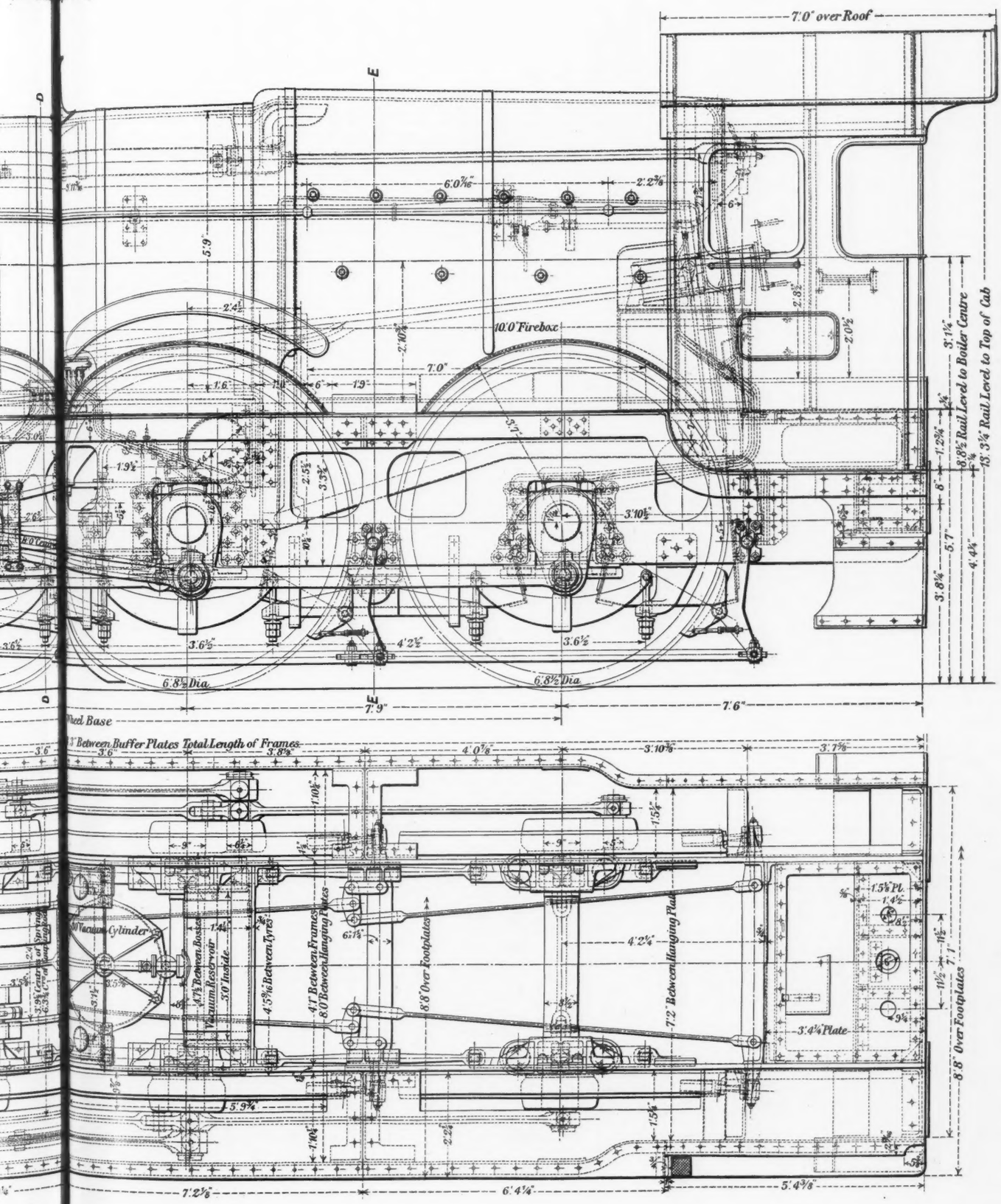

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Two-Page Plate.—FOUR-CYLINDER 4-6-0-TYPE SUPERHEATER LOCOMOTIVE FOR THE GREAT WESTERN RAILWAY

ENGINEERING.

FRIDAY, DECEMBER 14, 1923.

POWDERED COAL FOR STEAM RAISING.

PROGRESS in every art follows along similar lines; there is steady and continuous improvement in detail up to a point when perfection in technique seems nearly attained, and then some decided change in practice occurs which in turn is followed by a slow approach to some other ideal. The reciprocating steam engine is a case in point. This had almost reached finality in design when the steam turbine was evolved and the older prime mover found itself relegated to quite a minor position with regard to the development of power. No such drastic change has ever taken place in connection with the generation of steam, although it may be possible that we are near the limitations of firing large power station boilers with solid fuel. The possibilities of hand-firing in power stations were long ago exhausted, and mechanical stokers of some kind have become universal. Any further change in practice will almost certainly be in the employment of fuel in a pulverised form, either because this is found to be more efficient, or commercially more economical, or for the reason that it is found impossible to build satisfactory mechanical stokers of sufficient size to fire the enormous boilers to which modern practice is tending.

It may be that all of these considerations will have their effect in bringing about the change indicated, but it is certain the bigger the boiler unit the more likely the engineer is to turn to powdered fuel firing as a release from his difficulties with mechanical stoking. A boiler of a normal steam producing capacity of 50,000 lbs. per hour is not considered particularly large to-day, and four such boilers, working at their rated capacity, would hardly supply sufficient steam for one 20,000-kilowatt turbo-generator. Nevertheless, each of such boilers might well require three chain-grate stokers 14 ft. long or so placed side by side to provide the grate area of nearly 300 sq. ft. necessary for the boiler to perform its duty. There is no practical difficulty in building boilers of three or four times the size indicated, and some are indeed in service, with the advantage of a reduction in fittings, attachments, valves, &c., which is very welcome in a boilerhouse. Every increase in size, however, puts an added responsibility on the stoking machinery, and this, in the nature of things, is impossible to duplicate. The stoker manufacturers have succeeded very well so far in supplying machines to meet the ever-increasing demands of the boilermakers, and are certainly able to fulfil the conditions in any existing British power plant, but their task is becoming continually more difficult. It is not merely a matter of burning so much coal per hour. The coal has to be burnt economically at all loads, as little unburnt fuel as possible passing away with the ash at full load, and no bare places on the grate when the load is light. The stoker must accommodate itself to rapid fluctuations in the demand for steam, it must dispose effectively of ash and clinker without trouble, and above all things it must be reliable under perhaps the worst conditions to which machinery can be subjected.

The universal use of mechanical stokers of one type or another in power stations shows how satisfactorily on the whole they perform their duties, and the figures we have published of the operating results of the Dalmarnock, Radcliffe and Blackburn power stations prove how very high a boiler-house efficiency may be constantly maintained, even with great variations in output, if the stokers are operated as they should be. It is nevertheless true that to keep this efficiency month after month necessitates the greatest possible vigilance and care, and it is claimed by the advocates of pulverised fuel that an even higher efficiency can be obtained with far less trouble by the use of coal in the powdered form. One may reasonably accept this statement, since the control of the fires and particularly of the excess air is considerably greater with a powdered fuel system, and in practice it is likely that even the best modern stoker installation would hardly come within 5 per cent. of the best pulverised coal installation in point of view of economy of fuel. Mr. D. Brownlie, in his paper on "Pulverised Fuel and Efficient Steam Generation," read last night before the Institution of Electrical Engineers, quoted a working efficiency of from 85 to 88 per cent. for the pulverised fuel boilers of the Lakeside station of the Milwaukee Electric Railway and Light Company, which is in the fortunate position of having a 60 per cent. load factor, and mentioned a guarantee of 89 per cent. for the Colfax plant now being erected in the States. These figures are certainly high, but it was also pointed out in the paper referred to that efficiencies approaching 85 per cent. are being now guaranteed in England for mechanical stoker plants.

There is room for endless discussion on the subject of both tests and guarantees, for the whole question of how boiler efficiencies should be computed is in a very unsatisfactory state, but we think there is quite enough experience both in this country and abroad to prove that coal can be burned to more advantage in a pulverised condition than in its usual form. This, however, is not sufficient to ensure the adoption of the system, as questions of cost have to be considered. The ordinary power-plant engineer is apt to imagine that the use of pulverised coal will involve prodigious expense in rotary drying kilns, special bunkers and crushers and other apparatus which almost requires another boilerhouse to contain it. In addition to this, he foresees danger from explosions, dreadful trouble with ash and slag, and dust and dirt everywhere. It is somewhat unfortunate that the first installation of powdered coal in a power station in this country was on what is known as the central system, and the amount of equipment certainly presented a rather formidable appearance. The fact that it has since been extended is sufficient evidence that it fulfilled its purpose in a satisfactory and economical manner, and that the anticipated troubles did not amount to anything very serious. Nevertheless, the preliminary drying of coal by heat before pulverisation, the collection and storage of the coal dust, and the arrangements for feeding it to the burners as desired, all of which are typical of the central system as usually carried out, are so many drawbacks, whether regarded from the point of view of the first cost of the installation, the room required to house it, or the trouble and risk of operating it.

Experience appears to prove that all this complexity of plant is unnecessary, and that equally satisfactory results can be obtained by pulverising the undried coal at the boiler-front as it is required and feeding it directly from the pulveriser to the burners. The machine employed is a fuel-regulator,

a pulveriser and a furnace-feeder all in one: it has the further advantage of supplying the necessary air for combustion, so that in general no artificial draught installation is required. There are now several hundreds of such machines in use in this country and abroad, mostly in connection with furnace work, and, indeed, we illustrated one installation in our issue of October 5th last. Their application to boiler-firing has been slower, but it is interesting to note that the Powdered Fuel Plant Company, Limited, are now equipping a complete plant of seven Woodeson boilers with machines of this type, this installation being the largest yet put down in Great Britain. The boilerhouse is of precisely the same height and area as it would have been for stoker-firing, the pulverisers, with their motors, occupying approximately the position of the usual stoker-fronts. As soon as this plant has been at work long enough for reliable results to be obtained we hope to publish a full description of it. Another interesting installation of powdered fuel in this country is that at Peterborough Power Station. In the extensions to this station which were formally opened last September, Mr. W. M. Selvey decided to put down four Spearing boilers, each having a heating surface of 5,250 sq. ft., two of these boilers to be fired with chain-grate stokers, and two with pulverised fuel. In this case the Simon-Carves unit system of pulverised firing was adopted. Pulverism is effected at the boiler fronts, and the powder immediately delivered to the furnace. The portions of the boiler house devoted respectively to the stoker-fired boiler plant, and to the dust-fired boiler plant, are exactly similar in area, shape and height, so that no extra cost on account of building has been incurred by the system of firing adopted.

Unit installations of the type referred to are easily able to compete with mechanical stoking in first cost, so that the advantages of being able to burn extremely low-grade fuel, and obtaining a high boiler efficiency in addition are likely to lead to a considerable increase in the use of pulverised coal in the near future. Recent tenders for the equipment of a single boiler having a maximum evaporation of 65,000 lb. of water per hour, showed that sums varying from £2,700 to £3,400 were asked for mechanical stokers, whereas a pulverised coal installation was offered for less than £2,200, or with complete stand-by plant, which was not, of course, included in the stoker offers, and would serve as a stand-by for future extensions, for about £3,200. The boiler setting has, of course, to be somewhat different, but this is not a great matter in the case of boilers with steeply-inclined tubes, as these boilers lend themselves particularly well to the use of powdered fuel, because of the ease of procuring the large and deep combustion chamber which is so desirable. In any case the changes are all in the direction of greater simplicity while the abolition of the furnace arch, which seems to be a necessary evil with chain-grate stokers, will compensate the engineer for a lot.

The cost of pulverising coal may be divided, like any other manufacturing cost, into the capital charges on the price of the installation, and the expense of operation and maintenance of the plant. The initial cost, if the unit system is adopted, may safely be taken as not greater than that of mechanical stokers, even for very small stations. The operation, so far as labour is concerned, is also not greater than that of a stoker plant. The pulveriser, however, takes power to the extent of about 22 k.w.h. per ton of coal pulverised, and to produce this power will require about 2 per cent. of the fuel burnt. As against this we have the elimination, in most cases, of the induced draught plant, as the pulveriser acts also as an effective blower. Maintenance costs form the remaining item to be considered, and there is no reason to believe that these should be any heavier than those of a mechanical stoker plant. It has, however, we think, been proved that the pulverised coal system will deal with far cheaper grades of fuel than any mechanical stoker can effectively handle, and will burn any ordinary class of fuel with exceptional efficiency.

The position at present is that the use of pulverised coal for boiler firing has well passed the experimental stage, and the engineer responsible for laying down new boiler plant can get sufficient guidance from practical experience of the system to form his own opinion as to whether or not to adopt it. It has been largely, but not by any means universally, decided on in the case of recent American power stations, some of the most enterprising engineers on the other side of the Atlantic having come to the conclusion that, taking everything into consideration, mechanical stoking was still preferable for their conditions. We have not heard of any instance in which pulverised coal firing has been replaced by older methods, whether for furnace or boiler work, and we have known more than one case in which it has effected a very marked saving. British engineers, with their very high regard for reliability, are, we think, more likely to prefer the unit system in which the apparatus belonging to each boiler is independent, over the central system in which a breakdown of certain parts may affect the whole station. The lower first cost and the much greater simplicity of the former are also points in its favour. The central system at present holds the field, we believe, in respect of the number and importance of the plants equipped, but whether it can continue to do so time alone will show.

THE FRENCH RAILWAYS.

The working results for 1922 of the six French railway systems give evidence of the efforts made by them to balance their budgets. At the close of 1920 their total deficits amounted to close upon 3,000 million francs; at the close of 1922 the excess of expenditure over gross receipts—reckoning under expenditure not only the working expenses, but also all other charges, as will be detailed further on—had fallen to 1,150 million francs. It is quite possible, however, that for the present year, 1923, the working conditions will prove more costly than for the preceding one, owing to the rise in the cost of coal, rails, raw materials, labour, and to an increase of interest, &c., on loans.

Dealing with the various railway systems separately and taking in the first place the Paris-Lyons-Mediterranean Company, we find that the gross receipts for 1921 for this company amounted to 1,670,825,186 francs, and the working expenditure to 2,077,302,472 francs, leaving a debit balance of 406,477,286 francs. The working during 1922 shows a slight increase in traffic and a saving in actual expenditure. Taken as a whole, the gross receipts of this company show an increase of 135,000,000 francs, or about 8 per cent. above those for 1921. The increase is 14·3 per cent. for fast goods traffic, 7·2 per cent. for ordinary goods traffic, and 4·4 per cent. for passenger traffic, compared with 1921. At the same time the company has been able to reduce working expenses without interfering with the adequacy of the service, notwithstanding an increase in gross expenditure. The passenger trains in 1921 ran a total of 50,000,000 km. (31,075,000 miles), or 89 per cent. of the figure for 1913; the figures for 1920 and 1921 were respectively 57 per cent. and 73 per cent. of those for 1913. A number of motor-car services are now operating in the different tourist districts served by the company. The cars worked during the summer of 1922 daily runs totalled 6,130 km. (3,810 miles), as against 4,270 km. (2,653 miles) in 1921 and 2,760 km. (1,715 miles) in 1913. With reference to the increase in fast goods traffic we may state that the Paris-Lyons-Mediterranean Company, in combination with the Northern and Eastern of France Railways, contributed to the formation of the French Cold Storage and Transport Company, the business of which has greatly developed of late, the principal articles of food dealt with proceeding from Boulogne, Havre and Marseilles. The 7·2 per cent. increase in the amount derived from ordinary goods traffic has been secured notwithstanding notable reduction in rates for the carriage of raw materials and articles of primary necessity, granted with a view to the re-establishment of economic conditions in the country.

The advantages which attach to the development of international traffic have led the principal European railway systems to combine together at the request of their respective governments to form an International Railway Union, having central offices in Paris. The object of the Union is to secure unification and improvement in the conditions governing the working of the different systems with a view to facilitating the international intercourse aimed at.

The Paris-Lyons-Mediterranean Company is steadily proceeding with the construction work it has undertaken with a view to increasing in the near future the number of passenger tracks serving its Paris terminus, both for main line and for suburban traffic. It has also improved traffic connections at junctions in close proximity to Paris and at other centres of its railways. The traffic control system installed on the Dijon-Lyon section having given good results as regards economy of power and staff, and increase in the capacity of the lines, coupled with greater regularity in service, the system was, in 1922, extended to the Paris-Dijon section and has been in use since the commencement of the present year. An extension to the Lyons-Marseilles and Marseilles-Vintimille sections is contemplated for the near future. The company has also rapidly developed the use of cab-signalling.

The locomotives owned by the company numbered 3,571 at the end of 1913, 4,786 at the end of 1921, and 4,995 at the close of 1922. The new units, both for passenger and goods service, are all of powerful types. On December 31, 1922, the company had still due, on former orders, four electric trial locomotives and 193 heavy steam engines. In its programme for the electrification of certain lengths of its system, the company has decided to use to the greatest possible extent current supply from private undertakings. For the first line to be electrified, that from Culoz to Modane, it has entered into a contract with the Ugine Works and power companies for the necessary current. At a later date, the section from Carnoules to Vintimille, with branch line to Grasse, is also to be electrified, the current being supplied by a local company.

The company completed in 1922 the electric lighting of passenger carriages on fast trains; the work is proceeding on the carriages for suburban service and luggage vans. The strengthening of the coupling gear is completed as regards a portion of the rolling stock and is further being dealt with. The use of the Westinghouse brake is to be generalised and extended to the continuous braking of goods trains.

The fleet, formed during the war, and placed under the management of the Société Nationale d'Affrètements, consisted, on January 1, 1923, of 18 vessels having a total displacement of 121,600 tons. These vessels, together with those belonging to the Société, and others on time charter, transported, in 1922, 588,000 tons of British and German coal, equal to about one-quarter of the deliveries for the year, not including 65,000 tons supplied to the company's Algerian railway service.

The expenditure on the staff was higher by 11·6 per cent. in 1922 than for 1921, although the number of employees decreased from 116,000 to 113,000, a decrease which took place notwithstanding the increase in traffic following upon improvements in organisation. The conditions under which the 8-hour day law is applied have also hindered savings under this head. The allocations which employers have now to grant to their employees greatly exceed those in force in the preceding year; the railway systems now have to pay the cost of living indemnity of 720 francs per year, previously paid by the State; further, a sum of 50,000,000 francs had to be set apart in 1922 for increasing the pension fund.

The gross receipts in 1922 amounted to 1,806 million francs and the working expenses to 1,599 million francs, leaving a surplus of 207 millions and resulting in a ratio of working expenses to gross receipts of 88·5 per cent. These figures are an improvement on those of the preceding year. By adding, however, to the working expenses the interest on capital and on loans, together with other charges, the total expenditure becomes 2,050 millions and the difference is a deficit of 244 million francs, as against an adverse balance of 406 million francs in 1921.

The tracks of the Paris-Lyons-Mediterranean system have a total length of 9,781 km. (about 6,000 miles); with the lines under construction and those to be laid in the near future, the total length is 10,187 km. (6,330 miles). The company's Algerian system has a length of 1,075 km. (668 miles).

The system of the Northern of France Railway

Company suffered extensively during the war, as we reported in a former issue.* When dealing with the work of making good the devastations, a classification of the system into zones was adopted, one zone "of normal destructions," if we may use the term, being located towards the south, with a "chaotic zone" separating it from the "zone of systematic destruction," a destruction which the enemy carried out without any regard to the possibility of eventual reparations. Reconstruction of the system may now be considered complete. The work still to be dealt with has reference to a few stations, the schemes for extending and improving which are not yet finally settled. By thus rapidly making good the havoc caused by the war and by the enemy, the company has greatly helped the country in the vital matter of re-establishing her industries.

The train kilometrage, both passenger and goods, during 1922 was 50,897,662 (31,633,300 train-miles). The receipts amounted to 1,170,623,275 francs and the working expenses to 1,060,969,557 francs, showing thus a surplus; owing, however, to the numerous extra charges now to be borne by the company, operation during 1922 shows a net loss of 124,672,027 francs, which, it is satisfactory to note, is less than half the deficiency for 1921; the deficiency in 1920 was about 4·6 times that for 1922.

The Eastern of France Railway Company also suffered greatly through the war. On January 1, 1923, its rolling stock comprised 2,465 locomotives, 2,022 tenders, 4,136 passenger carriages and 73,255 wagons and luggage vans. The company has taken the necessary steps to complete in the current year the electric lighting of all its fast trains; the electric lighting of suburban trains is to be completed as soon as possible afterwards. A sum of 71,700,000 francs was set apart on December 31, 1922, for the provision of various safety devices, including the more extended application of the block-system, the installation of electric gong signals, locking devices, Westinghouse brakes, speed indicators, &c. Heavier rails have also been laid on several parts of the railway. The system has a length of 5,027 km. (3,120 miles). The train-kilometrage was 44,803,567 km. (27,845,000 train-miles) in 1922, equal to an increase of 11 per cent. on the figure for 1921. The gross receipts amounted to 1,037,356,549 francs, and the working expenses to 848,186,243 francs. The ratio of expenditure to receipts was 81·76 per cent., as against 99·47 per cent. in 1921. In 1913, the last complete year before the war, the figure was 60·62 per cent. Taking into account all charges to be met by the company, the deficit for the year 1922 amounts to 7,109,397 francs, whereas the adverse balance for 1921 was close upon 160 million francs. This most satisfactory result is due both to increase in gross receipts and to decreased expenditure. The company believes that the year 1923 may not show such good results owing to increase in the cost of fuel and of most other raw materials.

A review of the working during 1922 of the Paris-Orleans Railway Company shows that it has had to contract for heavy loans to meet new expenditure, particularly for carrying out its electrification scheme, also for the payment of rolling-stock ordered in 1918, and for part payment of material handed over by the State after the war. The work done with a view to improving the service and providing for greater safety was more extensive in 1922 than in the preceding years, and covered the strengthening of tracks, improvements in signalling devices, development in the use of the telephone, devices for wireless time signalling, enlargement, remodelling and rebuilding of stations, depot centres, &c. At the close of 1922, the rolling stock consisted of 2,405 locomotives, 17 motor coaches, 4,134 passenger carriages and 58,458 wagons and luggage vans, &c. Since the war, the company has purchased 695 locomotives, 805 passenger cars and luggage vans, and 13,702 goods wagons. Bogie carriages, to the number of 445, ordered in 1919, and since delivered to the company, are used in regular express service. Six hundred and twenty-four locomotives have already been provided with signal recording devices, an equipment which is being fitted to others.

The electrification of a number of lines is being proceeded with actively. Several hydroelectric generating stations in the south and centre of France, together with sub-stations, are in course of construction for the current supply. The building of 80 motor coaches and of 200 electric locomotives for both passenger and goods traffic, ordered last year, is well advanced; 10 motor coaches and 10 locomotives will be delivered this year. The company has ordered besides 5 high-speed electric locomotives of different types for trial purposes; the first is to be delivered this year and the four others in the course of 1924.

The system had a total length of 7,795 km. (4,840 miles) on December 31, 1922, of which 323 km. (200 miles) were narrow-gauge. The gross receipts amounted in 1922 to 941,098,560 francs, and the working expenses to 910,984,400 francs. The ratio of working expenses to gross receipts is therefore 96·48 per cent. Allowing for interest and other charges, the expenditure totalled 1,178,421,109 francs, showing a deficit of 237,322,549 francs for the year.

Among the improvements carried out by this railway may be mentioned the provision of sleeping-car services, direct cars from Boulogne to Biarritz, a number of extra trains between Paris, the Atlantic Coast and holiday and health resorts in the South of France; also direct connection between Bordeaux and Geneva in conjunction with the Paris-Lyons-Mediterranean Company.

The system of the Southern of France Railway Company has a length of 4,094 km. (2,544 miles). The gross receipts in 1922 amounted to 442,982,188 francs, whilst the working expenses reached a total of 458,714,820 francs. The adverse balance was therefore 15,732,632 francs, showing a ratio of working expenses to gross receipts of 103·55 per cent. Allowing for interest on capital, &c., the deficit amounted to 156,381,028 francs. Passenger traffic developed during the year, whilst goods traffic increased to an even greater extent, and now exceeds the figure for 1913. During the year under review the company completed the overhaul and repair of its engines and rolling stock. This has enabled it to improve its train service between Bordeaux, Hendaye and Cerbère; that with Marseilles and Italy; with Lyons, Alsace and Switzerland. Communications between Paris and the Pyrenees have also been increased, a series of direct and fast trains having been organised in conjunction with the Paris-Orleans Company. A number of motor car services have also been established with Biarritz as a centre. The company is continuing the electrification of its system, and it is anticipated that by October next current for working many of its lines will be supplied from the Pyrenees to Bordeaux and Toulouse. Electric locomotives now work the service on the Pau-Tarbes section, and electric traction will be extended shortly to the Toulouse-Dax section.

Taking finally the State Railways, we find that they have a length of 9,011 km. (5,600 miles). In 1922, the gross receipts amounted to 1,041,715,707 francs, whilst the working expenses reached a total of 1,194,469,246 francs, showing an adverse balance of 152,753,539 francs, and a ratio of working expenses to gross receipts of 114·66 per cent. Allowing for all payments made by the railways to the staff and for other purposes, the actual deficit for 1922 becomes 382,681,477 francs. The locomotives numbered 3,745, and the electric motor coaches and locomotives 65; there were 6,657 passenger carriages, 6,172 luggage and other vans and 70,754 goods wagons. The staff, on December 31, 1922, comprised 93,228 employees, or 6,189 less than the total for 1921, and 14,750 less than for 1920. The different indemnities and grants to the staff during 1922, paid in addition to the wages, form 44 per cent. of the actual wages bill, without counting other concessions for which it is difficult to quote a money value, such as travelling facilities granted to the staff and their families, and full wages granted during holidays. The State Railways are proceeding with their electrification programme on the suburban lines. The removal of the Batignolles tunnel outside the St. Lazare Station is proceeding, and the work will shortly be completed and the tunnel replaced by a cutting and by a wide bridge at one part. The work is estimated to cost 14,000,000 francs. Among the various trials carried out on this system may be mentioned those with engines driven by internal combustion motors instead of steam on lines having but comparatively small traffic, on which the working expenses are out of proportion with the receipts. The trials have demonstrated for this method of haulage decreased cost on engines, decrease in the staff, reduction in the cost per train-mile and lesser time required for getting the engines ready for service.

* See ENGINEERING, vol. cxi, page 782.

THE SMITHFIELD SHOW.

THE professional interest of engineers in the annual show of the Smithfield Club lies rather in the exhibits of agricultural machinery which have for so long been a feature of the occasion, than in the well-nourished animals whose breeding it is the function of the Club to encourage. The Show, which has occupied the Agricultural Hall at Islington from Monday until to-day, is remarkably like its predecessors. The animals, whose proportions constitute the main attraction of the general public, are staged in the centres of the main and Gilbey halls, while around the sides of the halls and in the galleries are engines and implements exhibited by manufacturers desirous of taking advantage of the presence of the large number of agriculturists drawn from all parts of the country to Islington at this time of the year. It is difficult to point to any feature of the present show which is significant of any change in agricultural practice, or which seems likely to produce any change. The extremely depressed state of agriculture renders the farmer unable to purchase even the standard machines and implements which he requires, and the consequent loss of the home trade, coupled with the impossibility of effecting appreciable sales abroad, has placed many of our agricultural machinery manufacturers in a really serious predicament. It is no good developing new machines at home if there is no market for them, and we are confronted with the fear that when trade does revive, British makers may find themselves so far behind in design and experience that they are unable to supply the wants of their customers so well as their foreign competitors.

This state of affairs has fortunately not yet been reached, for in traction and portable engines, steam tractors and steam wagons, thrashing, cleaning and elevating machines, and indeed, in many other products the British manufacturer can admittedly give a far better article and at a lower price than any foreign maker. With regard to reaping machines, hay loaders and certain other implements, the position is not so satisfactory, and the British farmer cannot be blamed if he takes advantage of the cheaper imported article when he is hard put to it to purchase one at all. The small hopper type petrol and paraffin engines which fulfil so many uses about a farm, were, until a few years ago, almost exclusively of foreign manufacture, and the foreigner has still a good hold on the market, but since such firms as Messrs. Ruston and Hornsby, Limited; Crossley Brothers, Limited; Drummond Brothers, Limited; Petters, Limited; Bamford's, Limited; and many others of equal merit have produced a British-made alternative, our own manufacturers are rapidly capturing a field, which, with a little more enterprise on their part might have been theirs from the beginning. It is to be hoped that some similar serious effort will be made to supplant the large amount of imported reaping machinery by equally efficient and cheap machinery of British manufacture, for an industry which cannot effectively compete in the home market cannot expect to develop the export trade upon which its highest prosperity will depend.

Cable ploughing tackle, in the manufacture of which British firms have always held the first place, is represented at Islington by the exhibits of Messrs. John Fowler and Co. (Leeds), Limited, and of Messrs. J. and H. McLaren, Limited, of the same city. Messrs. John Fowler and Co., Limited, show a compound steam-cable ploughing engine, and a 70 b.h.p. motor-cable ploughing engine, the latter fitted with a single cylinder air-cooled engine for starting purposes. The motor tackle is a very imposing machine, fully up to the traditions of the makers, both as regards design and workmanship. In considering the application of the internal

combustion engine to the duty of cable ploughing by either of the two firms mentioned, one cannot help wondering whether the relatively high speed vertical engine of the "motor-car" type adopted by British makers is any more suitable for the work than the much cheaper, simpler and apparently more robust arrangement of a powerful open-type single-cylinder horizontal engine adopted on the Continent. If it is not, and this, we think, would be the opinion of practical farmers who make a comparison between the types, our manufacturers may be on the way to lose their pre-eminence in this class of machinery.

Steam tractors to comply with the regulations of the Light Locomotives Act are exhibited by Messrs. Aveling and Porter, Limited, of Rochester; John Fowler and Co., Limited, of Leeds; Richard Garrett and Sons, Limited, of Leiston, Suffolk; J. and H. McLaren, Limited, of Leeds; W. Tasker and Sons, Limited, of Andover, Hants; and Messrs. Wallis and Stevens, Limited, of Basingstoke. Steam wagons also are represented, although we did not notice any motor lorries at the show. The steam wagons are both of the overtype and the undertype design, the manufacturers represented being Messrs. William Allchin, Limited, of Northampton; Fodens, Limited, of Sandbach; William Foster and Co., Limited, of Lincoln; and Richard Garrett and Sons, of Leiston, Suffolk. Agricultural motor tractors of British manufacture were shown by Messrs. J. and F. Howard, Limited, of Bedford; Martins Cultivator Co., Limited, of Stamford; and Messrs. Ruston and Hornsby, Limited, of Lincoln. Quite a surprising number of cream separators were to be seen on the various stands, by far the larger portion of them being of foreign manufacture, although often provided with most attractively English names. The British makers were the Wolseley Sheep Shearing Machine Co., Limited, of Witton, Birmingham and Messrs. R. A. Lister and Co., Limited, of Dursley, Gloucestershire. Sweden and Belgium seem to be the chief competitors in this class of machinery, but one separator, we understand, is manufactured by an American firm in Germany and imported thence into this country.

One of the most novel appliances we noticed was a small Swiss-made refrigerating machine, exhibited by Messrs. Richard Crittall and Co., Limited, of 43, Bloomsbury Square, London. This apparatus, named the "Autofrigor," is designed for the cooling of butchers' cold chambers or similar work, but it can, if desired, be used to make small quantities of ice. At the top of the machine is a small electric motor with its shaft vertical. This shaft terminates below in a crank which drives a small piston compressor. The lower part of the machine is a long vertical cylinder with numerous deep radiating fins. This cylinder is the evaporator. The refrigerating substance is methyl-chloride, the vapour of which is compressed by the compressor, and delivered into a condensing chamber surrounded by cooling water. From this chamber it flows through a pressure-reducing nozzle into the evaporator which is cooled by its expansion. The vapour is continually drawn back into the compressor and the cycle repeated. The whole of the refrigerating part of the apparatus is hermetically sealed, and there are no belts, valves, gauges, stuffing-boxes or other details to require attention. No recharging is required, no lubrication is needed and no skilled attention is necessary. The apparatus is made in three sizes, suitable for butchers' cold rooms, holding from 2 cwt. to 2 tons of meat. Refrigerating machinery of more usual type was shown by Messrs. W. and T. Avery, Limited, of 65, Long Lane, Smithfield, London; W. Douglas and Sons, Limited, of Douglas Wharf, Putney; Arthur G. Enock and Co., Limited, of Fountayne-road, South Tottenham, London; Ernest West and Benyon, Limited, of 82, Belvedere-road, London; and J. and E. Hall, Limited, Dartford, Kent.

Copenhagen Harbour Fees.—In view of the traffic experienced in 1922, the Copenhagen Harbour Board reduced its fees as from July 1, last by an amount equivalent to about half a-million kroner annually, and as the increase in traffic has continued during the current year, the Harbour Board has now decided, says the *Danish Foreign Office Journal*, to make a still further reduction of 20 per cent. in rates now in force as from the new year.

THE STUDY OF STRESS-STRAIN PROBLEMS BY MEANS OF RÖNTGEN RAYS.

Röntgen-ray researches, so triumphant in therapy and in the investigation of atomic structure and of scientific problems generally, have been somewhat disappointing to the engineer. The rays would, it was hoped, help the engineer in two directions. Since X-rays revealed the presence of metals in animal tissues as well as the structure of those tissues and of plants, enabled us to examine the quality of joints and of welds, and even showed unevenness, cracks and cavities in masses of steel, an inch and more in thickness, it was thought, that they might also disclose flaws in large blocks of metal which hardly admit of examination by other methods. But the recent advances in deep therapy have hardly benefited the engineer in that respect. Nor has much been achieved so far in realising the further hope that X-ray studies would give us a better insight into the nature of cohesion, which must ultimately depend upon atomic and molecular structure. Most of the work done—and a good deal has been done in this field—is, unfortunately, very difficult to interpret. In the radiograms of Dr. Czochralski, however, which we propose to notice now, we are able to watch the progressive changes which increasing fineness of grain and increasing amounts of stress and recrystallisation produce in aluminium. The radiograms, some of which are reproduced on this page and opposite, are exceptionally clear, and it would appear that the original method of Laue, which Czochralski uses in these researches, is more suitable for this purpose than its subsequent modifications, which have certain advantages in other classes of work.

When M. von Laue began his fundamental researches in 1912, it was believed, but had not been proved, that Röntgen rays were light waves distinguished by very short wave-length. Barkla had shown that the X-rays were dispersed by matter in the way that turbid media scatter ordinary light, but definite evidence of X-ray interference or diffraction had not yet been obtained. In the ordinary ruled diffraction grating, with about 14,000 lines to the inch, the widths of the slits and spacings are such that transmitted or reflected rays may interfere with one another. Such slits were far too coarse for experiments with X-rays which, from various estimates, could only have one-thousandth or less of the length of visible light waves. It occurred to Laue, then at München (now at Berlin) that the ordered grouping of the atoms in crystals should behave to X-rays as an ordinary grating behaves to light rays. The constants of such an atomic grating could be calcu-

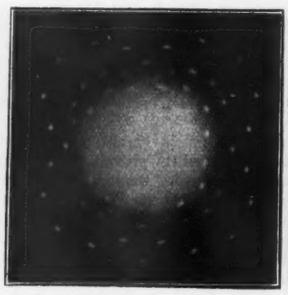


Fig. 1.

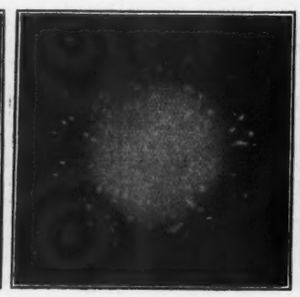


Fig. 2.

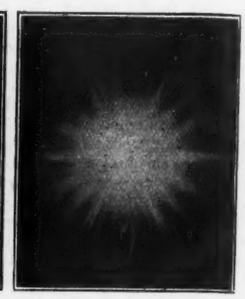
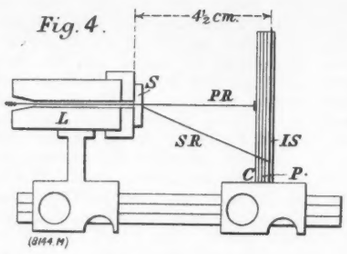


Fig. 3.



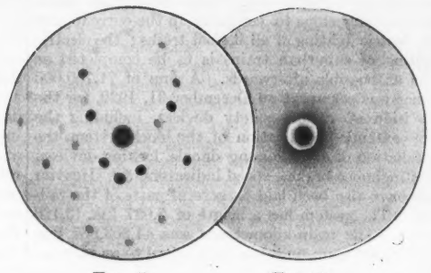


Fig. 5.

Fig. 6.

Fig. 7.

Fig. 9.

Fig. 11.

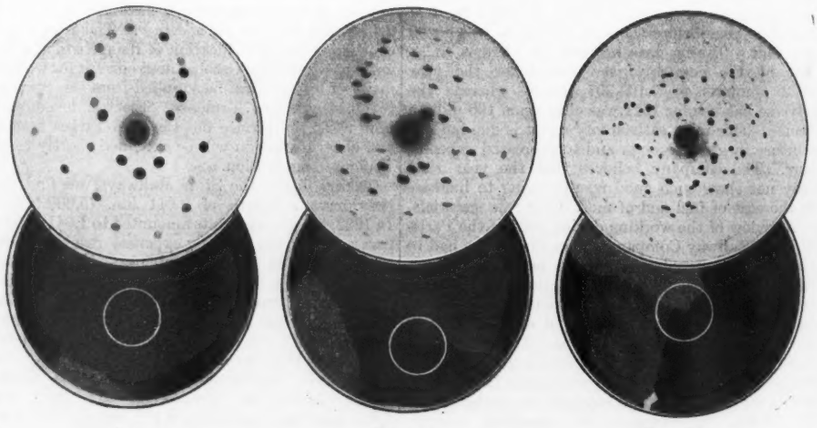


Fig. 8.

Fig. 10.

Fig. 12.

lated from the molecular weight of the crystallised substance, its density, the number of molecules and the crystallographic data and, assuming the wave-lengths estimates of Pohl, Sommerfeld and others to be of the right order of magnitude, diffraction phenomena should be observable. The calculations were obviously very complicated; for the crystal grating is three-dimensional, whilst we have only to deal with one dimension in ordinary gratings and with two dimensions in crossed gratings.

The experiments made on Laue's suggestion by W. Friedrich and P. Knipping quite confirmed anticipations. A thin pencil of X-rays was made to fall normally on the crystal round which several photographic plates were placed. On a plate, an inch or more behind the crystal, the central spot struck by the rays appeared black and surrounded by a pattern of small dots symmetrically grouped in concentric rings—presuming cubical crystals and normal incidence. With oblique incidence systems of ellipses are produced as in Fig. 5, opposite, presently to be explained. The dots mark intensity maxima of interference corresponding to the intersections of conical surfaces radiating from the several atoms.

The first memoir of his researches which Laue presented to the Bavarian Academy in 1912 mentioned several points which subsequent workers rediscovered. Various crystals were tried, whole and also in powder form; the thermal expansion of the spot hit by the rays was taken into consideration, and an attempt was made to discuss the phenomena on the supposition that the emission of light should prove to be, not continuous, but discontinuous, in Planck's quanta. It was very difficult to determine the atomic grouping and the wave-lengths of the X-rays from measurements made on the superposed systems of dots, and other experimental methods were developed. We have already described in previous articles the crystal-reflection method of W. H. Bragg and W. L. Bragg, which gives a direct relation between the atomic spacings and the wave-lengths (ENGINEERING June 2, 1916, page 518), and the methods of A. W. Hull (June 22, 1917, page 600), and of Debye and Scherrer (July 6, 1917, page 17), while we have also dealt with other modifications, on these and other occasions.

For the particular investigation of stress problems the Laue diagrams obtained by early workers did not look promising. Fig. 1 shows a Laue radiogram of a crystal of rock salt; Figs. 2 and 3 show the same crystal, respectively, slightly and strongly bent and it will be seen that the regular dots of Fig. 1 are disordered in Fig. 2, and appear grouped to a star pattern in Fig. 3. The photographs of

FIG. 13.

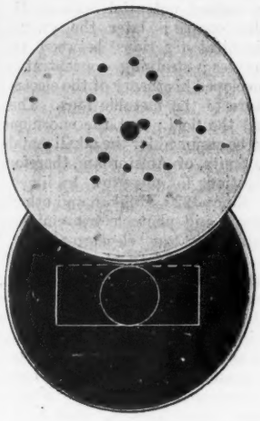


FIG. 14.

FIG. 15.

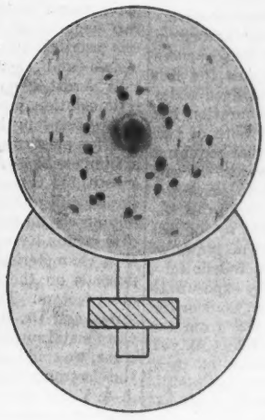


FIG. 16.

FIG. 17.

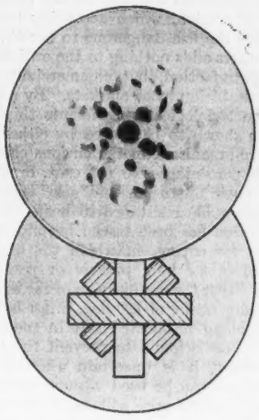


FIG. 18.

FIG. 19.

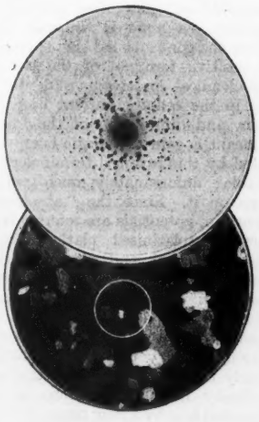


FIG. 20.

FIG. 21.

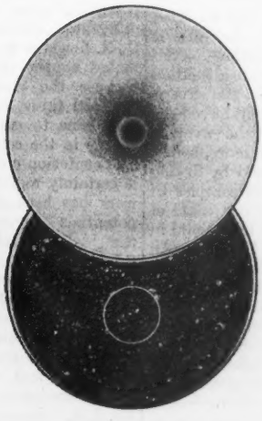


FIG. 22.

FIG. 23.

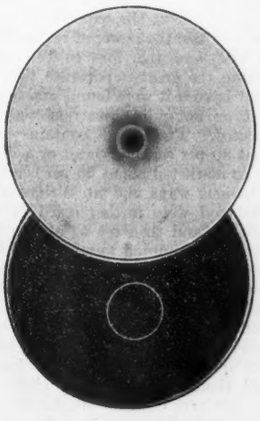


FIG. 24.

Dr. J. Czochralski, of the Metall Laboratorium of the Metallbank und Metallurgische Gesellschaft, Frankfurt, enable us to see how this grouping progresses. The experimental arrangement adopted is sketched in Fig. 4. The Röntgen bulb sends its rays through the perforation, 2 mm. in diameter, of the lead block L and its cover, on to and through the specimen S. The primary rays P R, which give the central dark spot in the photographs to be described, and the secondary rays S R, which produce the patterns of dots, pass on to the photographic plate P which is enclosed in a case C and backed by an intensifying screen I S. The usual thickness of the foil specimen is 0·5 mm. and the distance between the specimen and the plate case is 4·5 cm.; this latter distance is adjustable by means of the sliding mounting indicated in the diagram. In Figs. 5 and 6 we can compare the Laue radiogram of a single crystal of aluminium with that of an amorphous substance, amber; the former shows a characteristic pattern, the latter merely a halo of scattered rays.

In order to obtain specimens consisting of a single crystal or of multiple crystals, Dr. Czochralski made use of the method which he first described in 1916, in the *Internationale Zeitschrift für Metallographie*. A block of aluminium is rolled down in the cold and then recrystallised at about 600 deg. C.; specimens then taken show a uniformly fine grain. The metal is again submitted to tensile (or bending) stress and reheated to the same temperature as before for several hours. When only extended by 2 per cent. by this latter stress, the specimen consists of a few distinct large crystals which can easily be obtained with parallel surfaces, free of crystalline surface flaws, and in suitable thickness. As the stress is increased, and the extension rises to 4 per cent. and more, the number of crystals per unit area increases, and the grain becomes finer and more regular. Magnified photographs of these specimens, both of single and of multiple crystals, are shown in Figs. 8, 10, 12, and some of the other figures, in which the circle marks the spot hit by the rays.

In Fig. 7 we see the Laue radiogram which the single crystal Fig. 8 gave. The dots of the diffraction pattern are round and grouped in regular zones. In the next pair, Figs. 9 and 10, the specimen has been shifted so that the one-half of the field covered by the pencil of rays belonged to one crystal and the other half to an adjoining crystal. The number of dots is larger, and some of them are distinctly semi-circular; we have here evidently two overlapping systems of patterns. In Figs. 11 and 12, the specimen has so been placed that four crystals are in the field; the dots are smaller, less distinct and their number is so large that it would hardly be possible any longer to trace them back to the individual crystals.

In the next series of experiments the rays were made to traverse several crystals, not at the same time, but the one after the other. For that purpose rectangular slabs were cut from the large single crystals, Figs. 13 and 14, and were superposed upon one another, as the lower diagrams of Figs. 15, 16, and 17, 18 indicate. In the first of these experiments two slabs were crossed at right angles, in the second four slabs were crossed at about 45 deg.; some of the dots, especially in the second diagrams, are quite irregular in shape, actual dots evidently overlapping.

Those two series of experiments should, combined, represent what we expect to find in X-ray examination of ordinary metals in which the pencil of rays will pass through a fairly large number of crystals lying near and behind one another. The radiogram should change with the number of crystals in the field, *i.e.*, with the diameter of the X-ray pencil and the grain of the metal under test. This is confirmed by the diagrams Figs. 19 to 24. In Figs. 19, 20, the field contains about 120 crystals, probably in two layers; in Figs. 21, 22, the number of crystals was of the order of 2,000 and the number of layers probably four; in Figs. 23, 24, finally the field contained something like 1,000,000 minute crystallites in many layers. As the number of crystallites increases, the dots become more numerous, more crowded and smaller, until we approach the halo pattern of an amorphous material of Fig. 6. There is another point to be mentioned. With increasing degree of dispersity, *i.e.*, with advancing reduction in the size of the grains, the intensity of the radiogram diminishes noticeably, much more than our figures indicate. For it was necessary to prolong the duration of the exposure 10 times and more in order to obtain distinct radiograms.

(To be continued,)

PERSONAL.—We are informed that on and after January 1, 1924, the name of the Oxford Steam Plough Company, Limited, will be changed to Messrs. John Allen and Sons (Oxford), Limited, the present business of the firm being much more extensive than the name borne by the company for the last fifty-five years would imply. The firm in addition to specialising in repairs of road rollers, wagons, &c., are the sole manufacturers of the Allen scarifiers. They also manufacture living vans, water-carts, &c., and fittings such as injector clack boxes, and needle-valve water-gauge and boiler test cocks, having an interesting exhibit of these products at the recent Public Works, Roads and Transport Exhibition.

NOTES.

Institution of Mechanical Engineers—North-Western Branch.

The annual dinner of the North-Western Branch of the Institution of Mechanical Engineers was held on Friday last, at the Engineers' Club, Manchester, under the chairmanship of Mr. Alfred Saxon. In proposing the toast of "Local Industries," Sir Holberry Mensforth, K.C.B., Director-General of Ordnance Factories, spoke of the responsibilities of engineers in dealing with labour questions and the increasing necessity for efficiency in organisation and control. To reduce costs, waste must be prevented rather than the continuance of the practice of making cuts in wages. Labour had an undeniable interest in the control of works, for where there was inefficiency in control labour was the first to suffer. Were statistics of production put before the men in a way which made their significance a matter of ease, many of the present-day troubles would disappear. It was a regrettable thing that when special abilities in handicraft were required only the oldest workmen were available, as the best of the younger workers were going out of the country. In reply Mr. Clare Lees, President of the Manchester Chamber of Commerce, compared the engineering and cotton industries, the one being of the type in which capital was expended to obtain increased means of production, while the other made use of the facilities the engineer provided to meet a demand for commodities bought out of income. Mr. John Taylor, President of the Engineers' Club, also replied and dealt with the necessity for increased output, with which the reduction of wages could be prevented. He then briefly sketched the work done for the Ministry of Munitions in the district and referred to the scholarship and maintenance fund provided by money raised in the area and asked assistance in finding employment for the young men who have been trained under the scheme. The toast of "The Institution of Mechanical Engineers" was proposed by Mr. G. A. Juhling, the chairman of the North Western Centre of the Institution of Electrical Engineers, and was replied to by Mr. Daniel Adamson, vice-president, who anticipated the fostering of increased interest in the Institution through the development of local branches.

Diamond-like Graphite.

Under the name of "Glanzkohle" K. A. Hofmann and C. Röchling, of the Technical High School, Charlottenburg, describe a modification of carbon, of silvery-white lustre, hardly attacked by chemicals which oxidise graphite, as hard almost as diamond, yet elastic, and in short something intermediate between graphite and diamond. The observation is not quite new. W. Luzi obtained a peculiar graphite of this kind, but too little in quantity for full investigation, in 1892. Modifying Luzi's process, Hofmann and Röchling (*Berichte Deutsch. Chem. Gesell.*, 1923, page 2071–2076) let the moderately-luminous flames of Teclu burners play upon glazed smooth porcelain, heated—in a Hempel gas furnace or electrically—to temperatures up to 1,300 deg. C. and more. A convenient arrangement is to place several inverted porcelain crucibles, fitted with perforated bottoms, over one another so that the flames pass through the perforations and annular spaces. Below 650 deg. C. the carbon of the flame is then deposited as soot, above that temperature more and more of the new material is formed, provided the porcelain surface be smooth and chemically inert. Smooth quartz is suitable; rough porcelain becomes coated with soot or a platinum-grey graphite resembling retort graphite; on highly polished steel plates the carbon settles as soot, even at 1,100 deg. C. The composition of the gas is also important; only methane and allied compounds (chloroform, &c.) give the new modification, whilst benzene and cyanogen yield grey graphite. The hardness of the deposit increases as the temperature of the porcelain is raised; formed at 900 deg. the deposit has the hardness of quartz, at 1,300 deg. it is not scratched by corundum. The density of the new product lies between that of Ceylon graphite (1·92) and that of the graphite fibres which Pirani and Fehse recently obtained by depositing carbon from gases on carbon threads at 3,000 deg. The electric conductivity is less that of Ceylon graphite. Optically and by X-ray examination the modification resembles diamond more than graphite. Purified by chemicals which oxidise ordinary graphite and amorphous carbon (boiling with strong acids, fusing with sodium sulphate), the modification contained 99·06 per cent. of carbon and 0·48 per cent. of hydrogen; no mineral residue was found. Hofmann considers that his Glanzkohle forms the hard cement of retort carbon, which consists of typical graphite and amorphous carbon.

The Preservation of Salt Fish.

In the report by Dr. P. C. Cloake on Red Discoloration on Dried Salt Fish published by the Food Research Board (H.M. Stationery Office, 1*s.* net) an unusual condition has been investigated, to which it may be difficult to find an economically practicable remedy. The condition consists in the appearance on the fish, usually salted cod, of a red discolouration, which according to some observers makes the fish dangerous to health, and according to others adds nothing to the ordinary consequences of putrefaction, but commercially makes the fish unsaleable on most markets. By a prolonged series of bacteriological experiments this colouration has been shown to be caused by either or both of two micro-organisms, of the curious class that require a high percentage—15 per cent. or upwards—of salt for their nutrition, and also appear to possess a considerable resistance to heat. The origin of the infection has been traced beyond doubt to the salt used for curing, in which the organism grows or survives for long periods or perhaps indefinitely, and either the sterilisation of the salt by exposure to a temperature of 120 deg. C. for half an hour or the use of an uninfected salt in rooms free from the infection is found to prevent the trouble. As yet, however, it is uncertain whether either of these methods can be used without adding more to the cost than the price will stand. A third alternative is to dry the fish to 15 per cent. moisture, when the organisms, and apparently putrefactive organisms as well, cease to grow. So simple a method of preserving the fish from bacterial decomposition would have much to recommend it, but unfortunately, so far as the experiments go, fish so dried is said to lose the power of reabsorbing the water it has lost, and therefore to be unpalatable. Considering the great importance that such a method might have if it were found practicable, the experiments are not quite as conclusive as might have been expected. Fresh cod contains on the average about 80 per cent. of water or a little more, salted cod as marketed about 56 per cent., and by drying in various ways and at various rates samples of salted cod were further dried to 25 per cent. of moisture, and then set to absorb all they could in a stream of running water at about 14 deg. C. All samples absorbed water rapidly at first, and then much more slowly, and after 25 to 30 hours' absorption practically ceased. Samples that had been dried rapidly in a vacuum over calcium chloride absorbed much more water, and absorbed it much more quickly, than those that had taken four to eight times as long to dry either at atmospheric pressure over calcium chloride or in the open air; but none of them attained the full 56 per cent. of the market article, the vacuum-dried in a typical experiment reaching something over 50 per cent. and the other two something over 40 per cent. while the market sample had gained some 7 or 8 per cent. On these facts the report concludes that the fish will not reabsorb the water so as to become once more palatable, and that the drying process is irreversible. This may be so, but the observations recorded in the report hardly seem to show quite as much. For all they tell us, no experiments were made on the effect of varying the temperature at which the fish was dried, which is not stated, nor the temperature of the water from which reabsorption was attempted. It is indeed not even stated that some heroic man of science submitted the samples to the adventurous experiment of tasting them, which, after all, is a more crucial test of palatability than the tables and curves of water content on which the report seems to rely for its conclusion that the fish was unpalatable. The report is said to be confessedly incomplete, because the writer had to take up other work, and the Board's Fish Preservation Committee hope to complete it, when presumably these points will not escape their attention.

Electrode Reaction and Equilibria.

The most satisfactory evidence of the real advance of modern science is perhaps to be found in the attempts, now generally made, to correlate mechanical, physical and chemical phenomena and to trace the observations back to fundamental problems. But that is hardly more than an encouraging symptom. Because general discussions like that held by the Faraday Society recently on "Electrode Reactions and Equilibria," soon reveal the uncertainty of what one would like to be scientific tenets. In introducing the discussion by a paper on "The Mechanism of the Reversible Electrode," Dr. E. K. Rideal had to state that the source of the electromotive force in the galvanic cell remains an unsolved problem. Volta saw the main source in the contact potential between the two metals of the couple; later the energy was ascribed to chemical reactions between the metals and electrolytes; studying concentration cells Nernst then developed his theory of the electrolytic solution pressure of the metallic ions. That theory has long held the field; but the enormous solution pressures to be assumed for the alkali metals are impossible. A. Smits, of Amsterdam, therefore substituted concentrations for pressures, leading to similar difficulties. Since 1920, Millikan and others, relying on thermoionic and photoelectric emission of electrons, have introduced the "electron affinity" as a characteristic property of an element, which depends on the cleanliness of the surface among other factors. That affinity is related to the Voltaic series, and Dr. Rideal showed how, starting with a clean metal surface in a vacuum, and then admitting a gas, we could account for the electromotive forces, the electron acting as an anion. On the other hand, J. A. V. Butler, of Swansea, showed in his "Kinetic Interpretation of the Nernst Theory," that Nernst had given an adequate and acceptable explanation, and Professor A. W. Porter pointed out that the thermodynamics of Nernst had been misinterpreted. The latter also protested against the term "single potential," since we could only determine potential differences, and against the renewed proposal of G. N. Lewis to reverse the conventional sign (which makes copper the positive terminal of the cell), because the electrochemical processes were the essential thing, and in the cell the current flowed from zinc to copper, and diminution of the free energy in the cell meant a gain of electric energy. The confusion created by this reversed terminology is certainly regrettable; unfortunately much good work has been done on it. Since the "absolute potentials" are uncertain, potentials are referred to the hydrogen electrode (platinised platinum in sulphuric acid and hydrogen) and standardised against the calomel electrode which is somewhat capricious. Professor Biilmann, of Copenhagen, in a paper on "Oxidation and Reduction Potentials of Organic Compounds," showed how his new hydroquinone electrode is very useful, and more convenient and steady than the calomel electrode, for determining affinity in such reactions, and Dr. J. N. Pring supported him by a long paper of his own. But what do we really measure and what does affinity mean? Similar questions arose in connection with the papers by Professors J. Heyrovsky, of Prague, and E. Baur, of Zürich, on "The Mercury-Drop Electrode" and "Electrode-Potentials," and the further papers on "Electromotive Equilibrium and Polarisation," by Drs. H. Ellingham and A. J. Allmand, by Professor A. Smits, by Mr. N. V. S. Knibbs, and by Mr. U. R. Evans (on "Gas Films and Over-voltages") brought up the highly-controversial questions of passivity and protective and non-protective films.

Fire Fighting Appliances for Japan.—His Majesty's Acting Consul at Osaka, Japan, reports that according to a statement in the local press, the recent fires in Tokyo and Yokohama have impressed the Osaka Prefectural authorities with the necessity of providing that city with adequate fire-fighting facilities, and they are therefore desirous of receiving the fullest particulars of fire-fighting appliances. Further details regarding this inquiry can be obtained on application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1.

LITERATURE.

History of the Great War, based on Official Documents. By direction of the Historical Section of the Committee of Imperial Defence. Naval Operations, Vol. III. By SIR JULIAN S. CORBETT. Longmans, Green and Co., 1923. [Price 21*s.* net.]

A MELANCHOLY interest attaches to this third volume of the official history of the war, by Sir Julian Corbett, who planned the arrangement and determined its contents, but did not live to see the volume through the press. He was able to complete the text, but its final revision had to be entrusted to another hand. Lieut.-Col. Daniel, who had been closely associated with the author, enjoyed his confidence and knew his methods, has no doubt fulfilled the task allotted to him with care and judgment, but one cannot resist the feeling that had Sir Julian seen his work as a whole, in correct perspective, he would have curtailed or omitted many of the descriptions which obscure the main issue. In recalling particular scenes, keenly exciting and of great dramatic interest as they necessarily are, trivial incidents acquire a disproportionate prominence, and though by exciting the imagination they add to the interest of the narrative, yet when viewed in relation to the whole, are seen to stop the historical development and may mislead the judgment. Apart from the prolixity that follows the attempt to be needlessly minute, a want of decision may be remarked in drawing a dividing line between naval operations and the conduct of the war in general. On many occasions, undoubtedly, the Fleet and the Army co-operated as one unit in manœuvres, and the efforts of the one would have been unavailing without the assistance of the other. In the Gallipoli expedition, for instance, the Army could not have delivered its blow, however impotently, if the Navy had not transported it to its destination, protected it with guns on landing, and hampered the enemy by the tactics of its submarines. But it should be clearly seen where the functions of the Navy end, and that it was injudicious to follow individual corps into action, trace their fortunes, and declare their heroism, though we admit it would require a very stern discipline to quit a scene whose description has thrilled a world, without a word of admiration for the gallantry of the troops, or of acknowledgment of the dangers they faced. The picture would be less complete and the book of less absorbing interest, but the account of the land tactics has sometimes the effect of making the Navy occupy a second place in the drama, and to deprive that arm of the service of the appreciation and reward which are clearly its due.

Still less does it seem necessary or desirable to use Government machinery and the privilege of examining official records, for the purpose of discussing those questions of policy and statecraft, that by controlling the course of the war led to the adoption of tactics of whose merits it is premature to pronounce opinion. The glamour of great reputations is not without its effect on individual judgment. While the authors of the policy are still with us, an atmosphere of prejudice exists, which is fatal to unbiassed candour, and the impartiality of the judge is liable to be warped by the arts of the advocate. The time for criticism is not yet, the collection of facts is all that is prudent, and it would be a misfortune if some of the judgments, expressed or implied, were accepted with the same entire confidence that we are prepared to give to the statements of fact. It may be admitted that these excursions into the regions of high policy add to the piquancy of the tale, though they do not enhance our opinion of the rectitude of ministers, or convince us of the purity of their motives. In the chapter headed "Salonica" this tendency to penetrate motives rather than record naval events is seen in its fullest development, and it is certainly diverting, if not uninstructive, to learn or to be reminded of the treachery of some and of the ineptitude of others, who figured in the tragedy of the Balkans. The prize played for was great and worthy of the leaders of thought and policy. The fate of Europe was balanced for a while on the small force that was collected in the trenches of Krithia, with the ultimate object of striking Turkey out of the German confederation and of rendering the investment of the Central Powers complete and irresistible. It was a bold plan but it failed, and in war successful issue outweighs brilliancy of conception. The plan failed by reason of acute jealousies, divided counsels, and incompatible interests. The price demanded by Ferdinand of Bulgaria for an uncertain loyalty was greater than Greece and Servia were willing to pay. Russia grieving under great losses and torn by internal dissensions was precipitate and fought a lone hand. Constantine of Greece practiced endless subterfuges with the view of drawing profit from whichever side proved victorious. Venizelos pursued a tortuous policy that defies analysis, and England stood committed to a venture that was too great even for the vast resources of the Empire. In comparison and side by side with these great issues that compel attention, the author has to record the operations of some enterprising submarine forcing its way into the Sea of Marmora, and achieving some small success, but these latter, however, they may be dwarfed by more momentous consequences, constitute "Naval Operations" as usually understood.

It must not be thought that within the period embraced, the author has no thrilling tales to tell. Early in the book the sinking of the Triumph is recorded, a disaster that taught us how feeble was the protection provided by nets against torpedo attack, and almost on the same page is given an account of the loss of the Majestic, a famous old ship, in whose design the whole thought and experience of the Victorian era had culminated. On the other side of the account is to be placed the destruction in the Rufiji River of the Konigsberg, the last of the cruisers that escaped when the German Fleet was encountered off the Falkland Islands. For eight months the Navy had been aware of her position, but she had successfully defied all the efforts that could be spared for her destruction, and had fought gamely to the last. Most of us can recall the thrill of satisfaction and relief with which we heard she had succumbed to the attack of monitors and aeroplanes, and that this menace to our communications was no more. What memories too does not the career of the Moewe awaken, whose mine-laying was so expeditious and successful, her commerce raiding so well planned, and her inspiriting tactics so faithfully copied. Then further we have the duel between the Alcantara and the Rena, a theme for a modern Marryat, when the two vessels fought each other to a finish, and went to the bottom together, one succumbing to a torpedo and the other sunk by deliberate fire after the removal of the crew.

Actions at sea provide, but do not exhaust, the nervous excitement of the time. We can live over again those anxious days when the Zeppelin was a terror and the morning newspaper was opened with fear and trembling. But we read the several accounts with very different feelings. Trained literary ability is enlisted to reproduce the excited sensation that a few bald paragraphs in a newspaper column were sufficient to create; and order and method replace the scanty and irregular information that the official censor allowed to filter through. But whether we are at Suvla Bay awaiting the complete evacuation of Gallipoli, that final blow to the greatest combined campaign that history affords, or fighting a passage up the Euphrates to Nasiriya, we are able to follow the operations with ease, measure the risks accepted, admire the enthusiasm exhibited, and recover much of the atmosphere that surrounded us when the issue was uncertain and our nerves unstrung.

The greatest interest attaches naturally to the account of the Battle of Jutland. The author has lavished infinite care on the construction of detail, devoting nearly one fourth of the book to the description of an engagement and to the analysis of the plans of the combatants. In addition to the information supplied by the Admiralty, he has had accounts from enemy sources, including that of Admiral Scheer, and he has been able to furnish maps recording the position of the ships every few minutes during the critical part of the battle. The future historian will have at his disposal a kind of kinematograph picture of the whole action, and will see the progress of the battle more completely than did many a commander who took part in it, hampered as many were by a sea mist whose opacity was intensified by the smoke of the guns. The picture is drawn with such accuracy and the facts are presented in such complete detail that every one will be able to draw his own conclusions in accordance with his competency and experience. No more material facts will be known, the whole of the evidence is before the public, who, being fully instructed by the Court, will be asked to give a verdict, or by answering a series of questions provide the grounds on which judgment will be concluded. To one question we have no doubt the answer will be unanimous and decisive. There can be no hesitation in asserting that the devotion to duty and the spirit of heroism is as urgent and as ready to the response of patriotism as in the days of Nelson and of Hood. The fearless handling of seacraft shows no deterioration. The acceptance of hazard in the discharge of duty is as pronounced as ever.

To the further question, who won the Battle of Jutland, the jury will probably give an evasive answer, or be guided by sentiment rather than by demonstration. In appendices, Sir Julian gives a list of the ships on either side that were damaged or missing, as well as of casualties, and those who claim a victory or defeat on arithmetical grounds, may give a categorical answer. But for those who look a little below the surface, who judge by the results on the opposing forces, who ask whether the ability of either belligerent to maintain his position on the seas was increased or diminished by the result of the action, the answer is less decisive. Before the action the German Fleet was compelled to hide behind its defences and protect itself by mine fields, while our fleet, whatever its superiority in numbers and material, did not dare relax its nervous watchfulness for a moment. After the battle the conditions were precisely the same, and it is impossible to imagine a more futile result as the outcome of the sacrifice of brave men and noble ships. Nothing was changed, the conditions were the same as they were months before and as they remained months after. There is still another question, which we are hardly bold enough to ask and certainly not to answer. Did Admiral Jellicoe increase his reputation by his exhibition of strategy and by the handling of his command. Did infirmity of purpose or indirectness of aim contribute to the uncertainty of the issue? Will his name be recalled among the great English Admirals whom the nation delighteth to honour? These are questions which cannot be answered during the lifetime of a great commander, and the jury must be composed of men of equal calibre to himself, capable of appreciating his limitations and his opportunities.

Town Planning and Town Development. By S. D. ADSHEAD, Professor of Town Planning, London University. Illustrated. London: Methuen and Co., Limited. [Price 10*s.*]

MUCH has been written on the subject of town-planning, its objects, and the advantages its adoption is supposed to offer, but the view taken has generally been partial, directed to the attainment of certain ends by those who are interested in some especial form of development, and are eager to recommend the steps by which they conceive their purpose will be best achieved. A comprehensive view of what is permissible under legal enactment, and of what it is desirable to attempt to ensure favourable progress without hampering future and unknown possibilities, has hardly been undertaken, and Professor Adshead has a comparatively unoccupied field in presenting the policy that should guide the sober leaders of town planning schemes. The enthusiast and the missionary by urging the picturesque and aesthetic side of the scheme have aroused public attention and created an intelligent audience, to whom Professor Adshead offers the less attractive stimulus of a prosaic text book.

The author limits the scope of his work to a review of the social and administrative conditions that influence town planning at the present time, but this limitation does not prevent him taking excursions into side issues, that describe how towns grew under the inexorable law of circumstance, acquired distinctive characteristics from local conditions, and blossomed and faded as time and competition fought for or against their growth. The problem now is to devise an arrangement that

will permit the extension of towns and populated areas in a manner that will best meet the convenience of the community, curtail the erratic tendencies of exuberant and unrestricted growth, and minister to the requirements of business and industrial enterprise. Usually the town has determined some of its prominent features before scientific development begins its work. The need for orderly arrangement has made itself felt before the services of the expert are invited. The town planner has not a virgin soil for his operations nor ample scope for the unfolding of original plans. His is the humbler task of correcting distortions, of forecasting the direction of town growth and increasing local amenities. The direction of these humble tasks is sufficiently hazardous. Port Sunlight may have grown up as the magic wand of a millionaire directed, but in that case the object was clearly defined, the interests were undivided, and the means for achievement were ample. Letchworth presents an example of the construction of a definite design, uncontrolled by previous haphazard development, existing social organisation, or vested interests that are apt to prove more powerful opponents than considerate wellwishers of recommended improvements. The founders of Letchworth imagined a model town, self-contained, with a limited population in which space was allotted to residential, recreative, and industrial areas. It was found, however, easier to conceive the town on paper than to develop it in practice. A long series of struggles was necessary to get land sold, drainage constructed, and a Garden City built, such as figured in the dreams of zealous directors. The war stimulated its growth and fostered its nascent industries. The experiment is too recent to enable us to decide on its merits, but the success has not been so phenomenal as to induce imitation on a large scale. The author reports that there is every prospect of Letchworth "becoming an important industrial town, and of its rapidly arriving at a stage in its development when it will have a very great difficulty in confining the number of its inhabitants to its scheduled 50,000."

Suburban extension and the construction of "Satellite" towns is apparently the proper field for the application of the principles of town planning, rather than the creation of independent towns. By a "satellite" town is understood one, that permits the inhabitants to enjoy all the material advantages of the neighbouring city to which it owes its birth, and to participate in the attractions of specialised effort, that only great centres of population can support, while at the same time possessing the rejuvenating benefits of a communal existence, impossible to units in a countless multitude of souls. It differs from an existing trade centre on the one hand, in that it can be specially devoted to fostering industries that can be carried on independently, and on the other, from suburbs, such as Tooting or Hampstead, so far as it enjoys the isolation that promotes connected social community. Of suburbs, as generally understood, the author speaks rather disdainfully. He apparently regards them as the outcome of a policy that has no higher aim than to cover unlimited acres of undeveloped land with houses, whither those engaged in manual or professional work in the adjoining monster town, may betake themselves at night. Mere shelter is provided by the jerry builder who has enjoyed undisputed sway, but a dull monotony rules, and civic life finds little scope or possibility for development. The housing scheme on the verge of a big city, says Professor Adshead, should not contain more than 500 houses for one class in one locality. Such a plan may exist in the original conception, but could not be long maintained. We all know the shifting character of suburbs, dependent as they are on the circumstances that brought them into being. They rise and culminate and gradually sink into disrepute and decay, as some newer suburb becomes fashionable, to run in its turn the same career of decadence. It is not a little surprising to learn how brief is the average cycle of growth and decline. Naturally the increase in the means of conveyance and transport tend to shorten the life of a suburb by providing facilities of escape from the centres of congestion, and experience shows that the period of prosperity is not likely to last more than fifteen years. Investors in real estate may well ponder over the rapidity with which radical changes are accomplished.

An important feature in town-planning is that described as "zoning" or the fixing of areas of utilisation. The ability to assign drastic limits of occupation to industrial or residential centres is a dangerous power to place in the hands of a public authority, whose decisions must be more or less controlled by an expert, for it is impossible to take into account the controlling influence of the capricious human factor, while to neglect it when indicating the particular lines that enterprise must pursue is to court disaster. The rigorous, unalterable adherence to a prematurely determined policy can, as the author well points out, do more harm than good, since it is easy to hinder progress and to defeat individual effort. Instances of favourable examples of "zoning" are furnished by Ruislip, Northwood, a residential suburb of London, where areas of definite extent are set aside for business premises and others for residential property, where the number of houses per acre is precisely defined. An unfortunate instance is quoted at Newcastle, where insufficient foresight in handling the general problem has proved detrimental to the increase of the Elswick Works, and simultaneously depreciated the value of high-class property. Such a regrettable result does not however condemn the principles of town planning or make less necessary schemes for promoting orderly and progressive development. Town planning Acts are as much preventive as they are constructive Acts, though generally the view is entertained that these Acts are directed solely to the building of towns. It would be more correct to regard them as safeguarding existing interests, than as encouraging town development, and the more this object and guiding principle is understood and followed, the greater the advantage they will confer on the community.

These Acts are very fully described and form not the least important section of an interesting book. The number of amending acts shows the difficulty in fitting a programme to an entirely new departure, and the need of an efficient guide. Previous to 1909, the project was unknown to Parliament, and no act had been drafted, having distinct reference to the considered development of a town. A few efforts due to private initiative had been attempted in the country, but there was little experience to guide the authors of the first Town Planning Act, which followed the model of the Swedish Act of 1907, and has required much amendment to make it fit existing circumstances. The substitution of the Ministry of Health for the Local Government Board as the controlling authority has increased the number of advisers, but has not made the intention of the legislature more easy to follow. The author successfully conducts us through the mazes that politicians have contrived to construct and shows how far the problem has advanced in a few years. Town planning from being the hobby of a few has advanced to the compulsory stage, for a recent Act compels every urban local authority, controlling a district with a population of 20,000 or more, to prepare a town-planning scheme by January, 1926, while all local authorities in England coming within the meaning of the Act are to start a scheme this year.

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"A NEW THEORY OF THE STEAM TURBINE."

TO THE EDITOR OF ENGINEERING.

SIR,—In "A New Theory of the Steam Turbine," by Mr. H. M. Martin (ENGINEERING, page 1, vol. cvi, 1918), rational expressions for the re-heat factor in steam turbines are deduced connecting the value of the reheat factor R with hydraulic efficiency η and the pressure ratio of expansion x both for superheated steam and steam expanding in thermal equilibrium from an initially saturated state. Diagrams for facilitating the calculation of the reheat factor are embodied in the Mollier chart accompanying this article.

The original equations are somewhat complicated and difficult to evaluate, but an approximate empirical equation for the superheated region is

$$R = 1 + 0{\cdot}265\,(1 - \eta)\log_{10} x,$$

which is correct to 1 per cent. on the range of $x = 1$ to 100 and $\eta = 0{\cdot}4$ to $0{\cdot}9$. Up to $x = 10$, which is about the limit usually found in practice, the error in the value of R is less than 0·3 per cent. A modification of the above formula which gives an even closer approximation is

$$R = 1 + 0{\cdot}265 \log x - 0{\cdot}275\,\eta \log x.$$

For saturated steam in thermal equilibrium

$$R = 1{\cdot}0 + 0{\cdot}075\,(1 - \eta)\log x$$

agrees with Mr. Martin's results within 0·3 per cent. on the range $x = 1$ to 100 and $\eta = 0{\cdot}5$ to $0{\cdot}9$.

Equations similar in type to these are also given in "Steam Turbines," by W. J. Kearton, but they do not appear to give such close results.

Yours truly,

T. BEVAN, M.Sc.Tech.

College of Technology, Manchester, December 7, 1923.

PHYSICAL TESTS FOR GREY IRON.*

By J. SHAW.

I VERY readily fell in with Dr. Swinden's wish that I would give you a paper on to-night's subject. It offered an opportunity of obtaining the views of trained metallurgists on the application of physical tests to cast-iron.

When you remember that the major part of practically all machinery and engines is made from this material it will be readily realised how important the subject is to the designer. I take it the sole object of including in a specification certain clauses dealing with the tensile and transverse strengths of cast iron, is to ensure that the castings made from that iron shall be of the right strength for the safety and successful working of the parts. How far do the usual specification tests give this information? Take the Crown Agents specification. "Cast-iron is to be made from best pig-iron, and must be close-grained, hard, tough and perfectly free from all defects or blemishes. The cast-iron test pieces must be cast with the broader side of the bar uppermost. Bars for making these tests must be cast and tested before the commencement of the contract, and at such intervals subsequently as the inspector shall direct. The cast-iron is to be of such a quality that a bar of the same 1 in. broad and 2 in. deep, placed on edge on bearings 3 ft. centres, shall not break with a less load than 30 cwt. suspended in the centre, nor with a deflection less than 0·3 in. Yet to this specification castings that do not exceed $\frac{3}{8}$ in. thick are asked for, and at the other extreme castings with no section less than $2\frac{1}{2}$ in. thick. Again, take the Admiralty. They usually specify "That test pieces are to be taken from such castings as may be considered necessary by the Inspector. A bar, 1 in. square, tested on supports 12 in. apart, shall bear a load of 21 cwt. without breaking. The minimum tensile strength shall be 11 tons per sq. in., taken on a length of not less than 2 in. The general practice for the latter is to cast a bar $1\frac{1}{4}$ in. diameter, turn this down to 0·798 in. for 2 in. in the centre. Here again, this specification has been used for small cylinders, $\frac{3}{4}$ in. thick, and at the other extreme flywheels with a rim thickness of 12 in. Many engineers specify either one or other of the above specifications without any regard to the type of casting they are asking for. I have within the last year had the last one asked for in connection with some chilled rolls with 1-in. chill, and the engineer of our largest urban district council specified the former for some compressor heads with a minimum thickness of $5\frac{1}{2}$ in.

Even the British Engineering Standards Association are not free from this fault to a lesser degree. The present pipe specification calls for the 2-in. by 1-in. by 36-in. centres, bar to give 28 cwt., with a tensile bar of 1·128 in. diameter in the centre to give $9\frac{1}{2}$ tons. Some of the 3-in. turned and bored pipes are only $\frac{5}{16}$ in. thick, and it is difficult to obtain the 28 cwt. on a 2-in. by 1-in. bar and machine that metal on the thin pipes.

I think most of you will agree that to cast the same size bar to represent each of the above important castings is not an ideal way of ascertaining the strength of the castings themselves. It is a fact well-known to present-day metallurgists and foundrymen that the physical properties of cast-iron, such as texture, hardness, strength, machinability, wear, &c., are greatly influenced by the rate of cooling from the molten to the cool state. In fact, with this metal it must be considered first, and of greater importance than the chemical composition of the metal itself, when considering it from the point of strength.

Cook, some years ago made an experiment which proved this by ocular demonstration. He had a wedge-shaped bar cast in dry sand from a metal containing about 1·25 per cent. silicon. The wedge was 3 in. by $\frac{1}{4}$ in. at the point and tapered up to 6 in. square in a length of 2 ft. After leaving it to cool, the wedge was broken in two lengthwise. The fracture ranged from close-grained white iron at the thin end to very open grain—with large crystals giving very little cohesion—at the other, and with varying degrees of closeness in between. Hardness tests by the drill method were made, and it was found that it took 40 revolutions 5 in. from the thick end, 56 revolutions in the middle, while at 5 in. from the point it took 70 revolutions to drill the hole to the same depth. Microphotographs told the same story. The one near the point gave the characteristic structure of white iron, being extremely hard and brittle. A photograph near the thick end shows extremely long flakes of graphite, some of them stretching right across the area under observation. The whole structure was one not suited for castings requiring strength. All the above points go to prove that the metal from which the wedge was cast would be altogether unsuitable for thin castings where strength and machinability were required, and was not the ideal metal for very thick ones. Yet it was such as would have been accepted, by any inspector under the usual tests for any of the castings mentioned before as examples, as excellent, seeing that a bar cast from the same ladle, $1\frac{1}{2}$ in. diameter, and turned down to 0·798 in. in the centre, gave a breaking strain of 15·74 tons per square inch.

Naturally, at this point three questions arise:—

1st. Under what conditions were present-day specifications developed? In short, their history.

2nd. If these tests in many cases are misleading, how is it the foundryman has accepted them for the last 100 years and complied with their requirements?

3rd. Taking it for granted a revision is needed, where are we to commence?

Taking the points in order there is no doubt we are indebted to the engineer for the application of tests. With the greater use of cast-iron it was necessary to arrive at a strength and the factor of safety before safe designs for the various buildings and machines they were called upon to construct, could be started.

In the year 1827, Mr. Hodgkinson commenced his well-known inquiry into the strength of iron beams at Sir William Fairbairns works at Manchester, and for many years afterwards he carried on these and other experiments dealing with the same subject, with great success. Although his main object was to obtain the best design for cast-iron beams for fireproof buildings, he, for purposes of arriving at the best mixture of pig-iron for strength in these beams, used separately cast test bars, 1 in. square, at 4 ft. 6 in. centres. The same sized bars were used to observe the effects of time and temperature on the deflection of beams having a permanent load of one-third and upward on various bars. When I tell you that observations on the same bars extended in some cases from March 11, 1837, to April 19, 1842, the slight increase in deflection being noted at intervals as well as the various temperatures, you will gather how extensive and comprehensive these several researches were. For further details I must refer you to the sixth volume of the Proceedings of the British Association or the book published about that time by Sir William Fairbairn. There is little doubt that the use of test bars for obtaining the supposed strength of the castings was based on the results of the above very elaborate series of experiments.

About 1845, with the introduction of iron made by blast furnaces using hot blast, an issue was raised that has not been quite settled yet. At that time it was generally conceded that iron made in this manner seriously deteriorated when compared with cold blast irons. The experiments made for the British Association, with a view of settling this point, were the first of their kind publicly undertaken. The number of pig-irons tested was 16, and it should be observed with one exception, the cold blast irons were greatly superior to the hot. The single exception was a No. 3 Canon iron, and this led the experimenters to the conclusion that the lower qualities of iron (those being numbered higher) were improved by the use of hot air, to nearly the same extent as the higher qualities were deteriorated (a conclusion we now know to be quite wrong).

To show how prevalent this opinion was (that hot blast deteriorated the quality) I may say that Low Moor, Dowlais, and another South Wales furnace, all tried using hot blast, but in each case it was reported that the iron was so much weaker by the new method, that the cold blast was resumed after a very short trial. The experiments in the United States were even more unfavourable to the hot blast, as shown by the following figures:—

C. Blast gave 14,140 lb. tensile.
Heated to 150 deg. F. gave 12,243 lb. tensile.
Heated to 200 deg. F. gave 12,970 lb. tensile.
Heated to 250 deg. F. gave 11,420 lb. tensile.

The pig-iron was No. 1 quality. The difference in the tensile strength of hot and cold blast iron from the same furnace was so great in several instances, that the officers engaged in the inquiry sought and obtained the most ample proof, that in every case the inferior metal had been produced from hot blast irons.

The analyses made in the laboratory attached to the Pikesville Arsenal are singularly confirmatory of the unfavourable opinion respecting the hot blast irons. The results of various analyses on irons prepared by the two processes were as follows:—

	C.B.	H.B.
Specific gravity	7·194	7·047
Tensile strength	26·859	18·993
Com. carbon	0·0836	0·0687
Graphite	0·0476	0·0600
Silicon...	0·0386	0·0593
Slag	0·0189	0·0375
Phosphorus	0·0228	0·0185
Sulphur	0·0014	0·0010
Manganese	0·1141	0·0960
Earths	0·0117	0·0146
Silicon and carbon	0·1219	0·1281
Silicon and slag	0·0665	0·0975
Graphite, slag and sil. ...	0·1051	0·1568
Graphite, slag, sil. and phos....	0·1280	0·1753
Total carbon	0·1312	0·1287
Graphite, slag, phos., sil. and earths	0·1411	0·1909

I leave each member to see how confirmatory these analyses are. I give it up, but it is a warning to people who dogmatise on results of present-day analyses. Coming now to 1878 I have culled the following notes from the presidential address given to the members of the Civil and Mechanical Engineers by Mr. R. M. Bancroft. He states "Test bars should be run each day as the castings are being made, and a good plan is to specify that the test bars must be cast on the ends of the castings. One test is that a bar 2 in. deep by 1 in. wide on bearings 3 ft. apart, with a load of 25 cwt. in the centre should give $\frac{1}{4}$ in. deflection, and carry 27 cwt. without breaking. A second test is that a bar 1 in. square placed at 4 ft. 6 in. centres should not break with a less load than 600 lb. placed on the centre. The above tests are for iron used in compression; when used in tension even higher standards are advisable. Some engineers insist that these shall be deadweights and that no strain shall be applied in any way by test levers: and, in important contracts bars must be cast in duplicate, one to test and the other marked with the date when run, and kept for future reference by the engineer." There is also a quotation from a paper by Zerah Colborn before the Society of Engineers showing how by remelting, the tensile strength was increased from 6 tons to 9 tons, melting a second time the tensile rose to 13 tons, while remelting a third time gave 15 tons tensile. We now know that the iron was too soft to start with and that the increase of strength was chiefly due to increase of sulphur, and a decrease in silicon and manganese, thus giving a finer structure.

This last date (1878) brings us to a time when I was seriously engaged making tests to comply with the above specifications. The only serious alteration made was to shorten the 1 in. square bar to 12 in. centres, so that it might be more conveniently cast on the casting. I well remember making large numbers of 1 in. square bars tested at 4 ft. 6 in. centres for the late Mr. G. Davis, chief inspector of the Lancashire and Yorkshire Railway Company. He always insisted on having these tested with a deadweight which was suspended on a pair of blocks, and then carefully lowered on the bar. He then measured the deflection. I have devoted time to this point, because I wish to show clearly that neither the metallurgist nor the foundryman had much to do with framing present-day specifications. I am afraid neither had much metallurgical knowledge when Hodgkinson published the results of his experiments. The engineers of that day were forced to obtain some reliable data, due to the collapse of a number of buildings using cast-iron girders. To quote from Sir William Fairbairn's book again, "On more than one occasion as many as 15 to 20 lives have been lost, and the aggregate loss of life and property from this cause has been very serious. This occurs generally when either the design or construction are confided to the hand of ignorant persons."

While it is to the everlasting credit of the engineers of that period that they tackled the question of the strength of cast-iron in the manner they did, there is little doubt some of their conclusions were wrong when viewed in the light of our present-day knowledge of cooling and mass action. This will be evident when considering a table (not reproduced—ED. E.), showing the results of many years labour, and giving the transverse strengths and other properties of the pig-irons made in the United Kingdom, at that time. Under the column "Quality" will be found the terms hard, rather soft, rather hard, stiff, &c. This was for irons required for the purpose of testing the strength of the brand of iron.

If these specifications in some instances defeat the object for which they were framed, How is it the foundryman has complied with them all these years? The answer is fairly simple. For the first fifty years the knowledge of the behaviour of cast-iron under certain conditions was arrived at by trial and error. It was generally accepted that certain brands of iron gave great strength (of which Low Moor is a good example), and that a No. 1 iron was better than the so-called inferior iron No. 3, though we know now that even a No. 5 iron is very much stronger than a No. 1 when used for a thick casting. There is little doubt the pig-iron then made was a much better product than we generally receive to-day, due to small furnaces working local picked ores, giving small outputs and regular working. The tests asked for (27 cwt.) would be readily obtained when using a No. 2 or No. 3 C.B. iron.

With the advent of hot blast irons with their much more variable structure and composition, also with the more common practice of specifying tests, trouble began, and there is no doubt many test bars were made from iron that never went into the casting. This in most cases was not done with any idea of cheapening the material, but for want of knowledge how to mix the various irons at hand, as often as from the lack of knowledge on the part of the engineer in asking for a test from a size of bar that bore no relation to the thickness of the casting it represented. Take a hydraulic cylinder with walls $3\frac{1}{4}$ in. thick. To get this tight under a ton to the square inch pressure, a metal must be used that would give you a mottled 1 in. bar.

The engineer then had the test bar cast on the casting. Frankly he gained little by this move. The main object of the founder was to place the test bar so that he obtained a cooling effect to give a structure the same as the casting as near as it was possible. For instance, if the average thickness of the casting was only $\frac{1}{4}$ in. he would place the 1 in. square bar as near the outside edge of the box as possible. For the hydraulic cylinder mentioned above, he would put his bar as near the casting as possible in order to obtain the full annealing effect of the thick casting and so soften the structure of his bar. Also there is little doubt the founder would soften his mixture somewhat to ensure the test on the bar. This compromise, to obtain the best average strength from both casting and test bar is one of the chief reasons why designers only allow $1\frac{1}{2}$ tons per square inch in their tensile calculations. It seems to me the sooner the engineer and foundryman get together and fix up tests that will allow the best service condition to be obtained from castings the better, but when an inspector of one of our large spending departments after hearing the above facts, states publicly that he is satisfied if he obtains his 11 tons tensile and a nice casting, you naturally see that he gets his 11 tons from his test bar, and your casting passes out of your hands.

From what has been said before it must not be inferred that you can put forward either a suitable test bar, or a mixture that will give you a maximum strength in all parts of a casting with greatly varying thickness. Take a ship's propeller with its tips $\frac{1}{4}$ in. thick, and the boss 9 in. thick and over. The mixture for a casting of this description must be a compromise, as must the size of the test bar.

The question of design in relation to this problem of tests and strength of castings is as vital as any of the points named before, and here again calls for consultation between the engineer and the founder. If it were possible to arrive at an agreement on all the points mentioned, there is little doubt that in many castings you could reckon on a safe load of about 3 tons per square inch. That would mean that many of the heavy scantlings could be reduced one-half, even if you still retained the thin scantlings in the same casting at their original thickness, thus giving a design of even thickness and

* Paper read before the Sheffield Association of Metallurgists and Metallurgical Chemists on November 20, 1923.

more even cooling and therefore stronger. This brings me to the last point. Can better specifications be drawn up?

At the International Foundrymen's Convention held in Paris last September, this question received serious consideration. There was a fairly general agreement that some modification of present methods was long overdue, both in the interests of the engineers and foundrymen. When it is remembered that 14 nations were represented and over 1,000 delegates attended, the movement cannot be over-estimated.

M. Portevin put forward for consideration the method for taking small portions from the actual castings themselves. This would appear ideal at first sight, but there are so many weak points about it when examined, combined with the fact that it was first put forward by M. Fremont as long back as 1909, without making any progress even in France, that for the moment it is out of the picture. Further work along these lines may lead to its application. Particulars are given in a paper read by M. Ronceray at Birmingham, in 1922, or in the Institute of British Foundrymen's Proceedings. The American Society for Testing Materials have adopted the test bar put forward by the American Foundrymen's Association in 1904. It states that the quality of the iron going into the castings under specification shall be determined by means of the "Arbitration" bar; this bar is 1¼ in. diameter by 15 in. long, which shall serve for both tensile and transverse tests. The bottom of the bar pattern is one-sixteenth less in diameter than the top, to allow for draught and the strain of pouring. Two bars are to be cast in one mould, the mould to be rammed evenly and fairly hard, thoroughly dried, and not cast till cold. The test bars are not to be removed until cold enough to be handled. The bars are first tested transversely, upon which the Americans rely, and the tensile test bar is turned down from one of the broken halves of the transverse. They divide the castings into three types. Castings having any section less than ½ in. shall be known as light. Castings in which no section is less than 2 in. thick shall be known as heavy, while medium castings are those coming in between these two classifications.

The loads specified are for transverse:—

—	Light.	Medium.	Heavy.
Load at centre .. lb.	2,500	2,900	3,300
Deflection at centre ..	0·1	0·1	0·1
The tensile loads are tons	8·0	9·3	10·7

Although this specification has been issued since 1904, our representatives, when visiting America, found that little use had been made of it. The fact that the whole question is again in the melting pot and a strong committee under the direction of Mr. Swann has been formed by the A.F.A. points to a weakness somewhere. The increased load asked for from a bar, 1¼ in. diameter when representing castings over 2 in. thick is fundamentally wrong. The drop from the mean load to 2,500 lb. for thin casting, while it is what would be expected from the softer iron required, also makes it possible to use an inferior iron to give the lower load. A little over two years ago the Institute of British Foundrymen co-opted a committee of one member from each of its branches, a member of British Cast-Iron Research Association, and a convenor. The results of their meetings were published in a tentative specification sent out to the chief technical societies for criticism, before submitting it to the final tribunal, the B.E.S.A., for modification or acceptance. The committee from the commencement realised that if the specification was to be of value when issued, it must carry the approval and consent of the engineers. They therefore had two objects in view. First to modify the tests so that the size of the test bars bore some relation to the castings they represented, and so would to a limited extent have a somewhat similar structure to the casting itself, and secondly, convince the engineer that the test loads on the modified bars were at least equal to anything he had asked for before. Once this specification has been tried out by both the engineer and the foundryman, there is little doubt that in revision an effort will be made to increase the strength of the castings. This tentative specification varies from present day specifications in a few vital points.

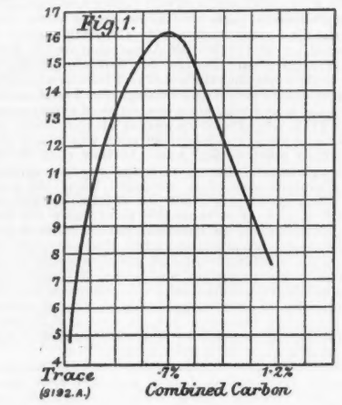
Clause 4 divides the castings into two grades, viz., Grade A is to include important castings, Grade B is to include all other castings which require to conform to mechanical standards.

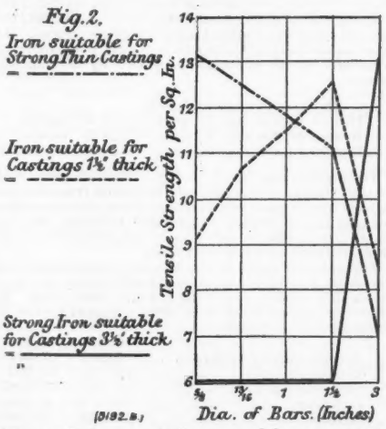
Clause 6. The average sectional thicknesses of any casting shall determine the size of bar to be utilised. Thus for all castings where no main cross-section of the metal exceeds ¾ in. thick a bar 0·875 in. diameter, cast 15 in. long, shall be used. For all castings where no main cross-section of the metal exceeds 2 in. thick, or is less than ¾ in. thick, a bar 1·2 in. diameter cast 21 in. long shall be used. For all castings where no main cross-section is less than 2 in. in thickness a bar 2·2 in. diameter, cast 21 in. long, shall be used.

Clause 7. The test pieces for Grade A shall be cast on the casting wherever possible. When practical conditions do not permit of this, or when the consent of the engineer is obtained the procedure outlined for Grade B shall be followed. The test pieces for Grade B may be cast separately at the option of the supplier, and shall preferably be cast in duplicate sets of two bars. The test bars shall be made of green sand or dry sand, according as to whether the casting to which it refers is moulded in green or dry sand.

The test pieces shall be cast from the same ladle as the castings, and as nearly as possible at the same pouring temperature. The test pieces shall possess the same thermal history as the casting it represents. (This is to provide for the growing practice of heat-treating certain work.) The test pieces may be tested transversely as cast, or skin machined at the option of the engineer. The transverse tests are as follows:—

—	Grade A.	Defl. in.	Grade B.	Defl. in.
	lb.		lb.	
The bar 0·875 tested at 12-in. centres shall give	1,185	0·12	1,050	0·1
The bar 1·2 tested at 18-in. centres shall give	1,950	0·15	1,715	0·12
The bar 2·2 tested at 18-in. centres shall give	10,000	0·12	9,000	0·10





The tensile bars are to be prepared from one portion of the transverse bar.

—	Grade A.	Grade B.
	tons.	tons.
The bar 0·875 shall be turned down to 0·564 in. in the centre, and shall give per sq. in.	12	10
The bar 1·2 shall be turned down to 0·798 in. in the centre, and shall give per sq. in.	11	9
The bar 2·2 shall be turned down to 1·785 in. in the centre, and shall give per sq. in.	10	9

Chemical Analysis.—Where physical tests are specified the percentage of any chemical element other than phosphorus shall not be specified, and then only its maximum percentage.

The committee fully realised from the beginning of their sittings that the test bar only represented the quality of the metal going into the casting, and not necessarily the strength of the casting itself. They also realised that a separate cast test bar is not an ideal method, but felt that in the absence of any satisfactory manner of testing the casting itself, without injuring it, their first duty was to modify the present-day tests so that they would be more satisfactory to the engineer and foundryman, and so enable a better product to be made.

In conclusion, I would call your attention to the two diagrams and the test results of 60 days' consecutive work.

Fig. 1 gives the result of work done by Professors Turner, Cook and others, showing that the greatest strength of any given iron is reached with combined carbon between 0·7 and 0·85 per cent. The recent talk and patents for producing a "Pearlitic" iron are but a confirmation of previous work. Now if you grant this point, and I think you must, it will at once appear how ridiculous it is to put forward one size of bar to represent all thicknesses of castings.

Fig. 2 shows the results of a series of experiments made on various sizes of bars with metal suited to various thickness of casting. The bars were ⅝ in., 13/16 in., 1 in., 1½ in. and 3 in. diameter. Each set of five bars was cast in one box from the same ladle. No. 1 iron was suitable for strong thin castings. On the ⅝-in. diameter bar we obtain 13½ tons tensile, and then, as the size of the bar increases, thus giving a more open structure, the tensile figure drops to 7 tons registered on the 3 in. bar. Iron No. 2 was suitable for steam cylinders about 1½ in. average thickness. This iron was too hard for the ⅝-in. bar and only 9½ tons was reached. There is a gradual rise till at the 1½ in. diameter bar 12½ tons was recorded, with a drop to about 8½ tons for the 3-in. bar. I want you to note that both these irons would have met the ordinary specification of 9½ tons on all bars up to 2 in. diameter. No. 3 iron which was used for hydraulic cylinders, cast every bar white up to the 1½ in. diameter bar. This was too hard to turn. The 3-in. bar was grey, as the samples broken showed. It was turned, sent to the Sheffield testing works and registered over 13 tons tensile per square inch. The total carbon in the metal was 3·2 per cent. The combined carbon in the 1·2 bar was 3 per cent. In the 3-in. bar it was only 0·9 per cent. Here, again, granting the conclusions in Fig. 1 are right. No. 2 only shows how impossible it is for a one size bar in any way to represent all thicknesses of castings.

In addition to the above points, there is a further complication, which I put forward with some hesitancy, not because I have any doubt about its frequent occurrence to a greater or less degree, but for fear the discussion may centre round it, rather than the main issue, namely, the best form of physical tests for cast-iron. I refer to what is often derisively termed "The inherent properties of cast iron," or in Sheffield as "Body." It means that two irons of the same analysis, cast, melted and cooled under the same conditions, may yield greatly varying physical results. Perhaps the best-known results are those published in a paper by Cook and Harlstone, where for 60 consecutive days melting test bars cast from a mixture of three irons gave an average of 15·8 tons per square inch. One of these irons being worked out, a new mixture was made up from two of the irons used before, together with a new iron to give approximately the same analysis. How near this was can be seen from the annexed table. Yet for the next

—	A. Series. 9·1 tons.	B. Series. 18·3 tons.
	per cent.	per cent.
Total carbon	3·25	3·192
Graphitic carbon	2·397	2·289
Combined carbon	0·853	0·902
Silicon	1·328	1·314
Sulphur	0·095	0·101
Phosphorus	0·923	0·909
Manganese	0·290	0·335

60 days' working the average tensile figure only reached 10·7 tons. The highest breaking load never reached the lowest of the first mixture. These results are not uncommon, but their value lies in the fact that the analysis and tests were checked by an independent metallurgist. You have the same testimony from Dr. Swinden, Pilkington, Houghton and others. Personally I have, being attached to a firm who ran their own blast furnace, found this variation between structure and analysis fairly common, the worst case being one where with silicon of 0·18 per cent. the pig-iron was grey, and mottled grey. The "Over Grey" iron is fairly common in most furnaces when changing over. I have a specimen which has an analysis of total carbon 3·24 per cent., combined carbon 0·25 per cent., Si. 2·89 per cent., Mn. 0·95 per cent.; S. 0·026 per cent.; P. 1·31 per cent.; yet the fracture is a No. 3, which fracture it retains on remelting. Wilkinson recently, in a paper before the Staffordshire Iron and Steel Institute, speaking in favour of mixing by analysis, stated "I have had trouble on several occasions during the last two years owing to the high percentage of combined carbon in some brands of West Coast No. 1 hematite. In nearly every case the fracture of the pig-iron showed large crystals and the combined carbon in such a pig-iron was naturally expected not to exceed 0·3 per cent., but it was found in many cases to be over 0·6 per cent., and in at least one case 0·7 per cent." The analysis of two of these irons were as follows:—

Combined carbon 0·533, Si. 2·157, S. 0·058, Mn. 0·876
Combined carbon 0·667, Si. 2·511, S. 0·06, Mn. 0·13.

Wilkinson, being a friend, I wrote asking him if in remelting the iron gave a fracture he would expect from the analysis. He confessed that it did not, nor would the test be what you would expect. Now I don't wish you to think I underestimate the value of chemical analysis. It is the only ground work to build on, but I think you will all admit, that either the analysis as we make it to-day does not go far enough, or that there are certain physical properties set up during certain furnace conditions, that make it possible to obtain such varying physical tests from iron of the same chemical composition, cast, melted and cooled under as near similar conditions as works practice will allow.

▼ SPHERICAL TANKS FOR OIL STORAGE.—According to *The Iron Age*, New York, a number of large elevated spherical steel tanks are being built in the United States for oil storage. The tanks are 48 ft. in diameter, and hold approximately 8,500 barrels. This new type of tank, invented and built by the Chicago Bridge and Iron Works, has been named the "Hortonsphere." It has been designed to withstand leakage, evaporation and an internal pressure as high as 15 lb. or 20 lb. per square inch.

THE MANUFACTURE AND REPAIR OF HEAVY STEEL CASTINGS.

*The Manufacture of Heavy Steel Castings for Ships, with Special Reference to Stern Frames, Rudders, Shaft Brackets and Stems.**

By HUGO P. FREAR.

(*Concluded from page* 729.)

Defects.—In the manufacture of steel castings there is unfortunately a large percentage of rejections on account of defects. It may not be an exaggeration to say that the closest scrutiny might reveal minor defects, more or less important, in almost every large steel casting. The foundryman can, however, take some consolation from the fact that many of these can be salved by electric welding or other means. The various characters of defects, resulting in rejections, arranged approximately in the order of their importance, are shrinkage cracks, shrinkage cavities or pipes, blowholes, surface imperfections, warping and cold shuts. Shrinkage and gases are, therefore, the chief offenders as far as the more common defects in steel castings are concerned. Hot metal, sudden changes in thickness, small fillets, sharp corners, quick bends, webs, flanges, internal stresses from uneven cooling, and unyielding moulds and cores all contribute to the possibilities of shrinkage cracks. These most frequently occur between heavy and light sections, in fillets, corners and at bends. A difference in the rate of cooling of thick and thin metal causes the lighter parts to shrink first and pull on the heavier parts still in a semifluid or weak state. If the metal at this point is sufficiently strong or the mould sufficiently yielding, a crack may be avoided.

It is good insurance, however, to take every precaution where these conditions exist, whether from poor or unavoidable design. Larger fillets may be fitted to advantage. Thin brackets, formed by the moulder in the directions of the strain, chill quickly, and by increasing strength help to resist pulling apart. Accelerated cooling by inserting chill plates at the proper place is perhaps the most effective. The thickness of the chill plates should be regulated by the thickness of the metal. They should be heavy enough to chill it without sticking. In less important cases heavy wire nails, closely spaced, are inserted in the mould where chilling is desirable, but the effect is comparatively ineffective. If this is over-done, chilling may take place before the nails melt and unite with the metal. This condition has been observed in a number of recent cases of stern frames fractured at the junction of the propeller post and shoe. On being cut apart for preheating and thermit welding, nails and large pieces of bar steel have been found embedded in the metal but not united with it. While this practice may have prevented a shrinkage crack at the time, it contributed to the fracture and is strongly to be condemned.

Thin brackets as described above to increase the strength by chilling quickly at flanges, webs, sharp corners, and bends are also used to prevent cracks. Every other known precaution to avoid shrinkage cracks may be employed, and yet, if the mould and cores are not sufficiently yielding, disappointing cracks may occur. If shrinkage is estimated at $\frac{1}{4}$ in. per foot, the contraction and the necessary yielding of the mould in a length of 24 ft. would amount to 6 in. The distance between the top and bottom gudgeons on the stern frames of many merchant steamers is at least 24 ft. It is therefore apparent, if cracks are to be avoided, that the mould must yield, in this case, about 6 in. between these two points, provided the casting is not stretched in the manner above referred to.

The writer has been informed that probably in the case of 75 per cent. of ordinary merchant steamers, on, or after, going into commission, small cracks exist either at the top or bottom or at both top and bottom of rudder gudgeons. It is also stated that these are being continually electric welded in dry dock. It cannot be said from personal knowledge whether or not this is an exaggerated statement. If as prevalent, as would appear from the above, more drastic methods should be adopted in the foundry to provide greater yielding of the mould at such points. The ordinary cinder or coke backing does not appear to be sufficiently effective. It would seem that a more yielding material could be used to advantage. Commander Carlos Bean, United States Navy, in the case of smaller castings of a certain design, has suggested a filler of sawdust. This has been tried out at one foundry for difficult but small castings with almost unbelievably good results.

Some of the gudgeons above referred to were said to be cracked both at top and bottom. If the metal expands just before, and contracts just after, solidification, as some claim, the top and bottom cracks might be accounted for by resulting alternate stresses. Whether or not this is entirely correct, it would be prudent to use a more yielding material on both sides of the gudgeons. Shrinkage cavities or pipes are formed more noticeably in the heavier sections by contraction as cooling proceeds. Freezing begins with the outer layer of metal in contact with the walls of the mould and gradually, layer by layer, works inward. As the freezing continues, contraction increases until the still fluid metal in the centre fails to fill the interior, and as its supply fails it leaves an unoccupied space termed a shrinkage cavity or pipe. The tendency of the pipe is to work upward by drawing metal from parts higher up still in the fluid state. The

FIG. 4. CRACK CUT OUT FOR WELDING.

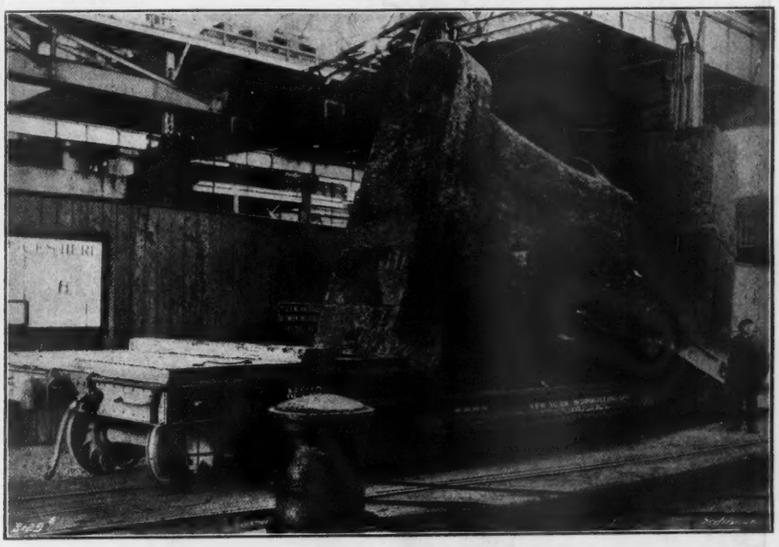


FIG. 5. RUDDER POST CASTING REPAIRED BY THERMIT WELDING.

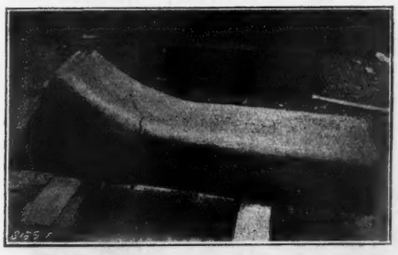


FIG. 6. BROKEN SECTION OF SHOE.

FIG. 7. SS. WEST NOSSKA; NEW SHOE WELDED IN PLACE.

* Abstract of paper read before the American Society of Naval Architects and Marine Engineers, New York, November 7, 1923.

total contraction amounts to about 5½ per cent., and this volume of fresh metal must be fed into the mould to fill the cavities. This feeding is done through sinkheads into which the pipes should finally rise.

Where possible, the heavier sections most susceptible to pipe should be at the top of the mould. Sinkheads should be located above these heavy parts and at various other points in long castings. They should be liberal in size and great care exercised that the metal in them does not freeze before the cavities are filled. Good judgment is required in determining the number, location and dimensions of sinkheads. This is important not only to insure sound castings but to reduce the scrap, which, on this account, may amount to a very large percentage of the casting. Blowholes are caused by gases given off in cooling, the evaporation of moisture in the sand, and air drawn in while pouring. If the gas and air does not escape completely through the risers, vents introduced in the mould and cores, or through the sand, blowholes will be inevitable. They are not infrequently the result of poorly made steel. As the whole heat is often required to make a large casting, it is difficult sometimes to determine whether the defects are due to the quality of steel, venting, sand or moisture. If one of several castings from a heat is sound, it may be concluded the metal is all right and the fault attributable to other causes.

Unless the mould is faulty, most of the air in the mould, or the air drawn in and the gases evolved during the interval of pouring, should readily escape through the risers or sinkheads. If this contention is correct, it is obvious that blowholes, if formed after the mould is filled, must be caused either by the gas evolved in the cooling metal or by contact between the hot metal and sand which, although seemingly dry, from the outside, may contain moisture under the surface. While fluid iron is not as hot as fluid steel, it is possible that the amount of gas evolved from contact of hot metal with sand would be greater between hot iron and moist green sand than between hot steel and thoroughly dried-out sand. On this account, and because green sand is not as porous as dry sand, iron moulds are vented much more freely than steel moulds. The burning gases from a large iron mould, as compared with those from a large steel mould, are more spectacular and indicate greater escape of gases through the mould. No amount of provision for the escape of gases through the risers and other vents will prevent blowholes if the sand is lacking in permeability.

If these externally escaping gases form blowholes, they must do so before the metal chills on the outer skin. As there are less of these particular gases with steel than with iron, and as steel chills more quickly than iron, the more frequent occurrence of blowholes found in steel must result from the soluble gases in the metal itself. When the silicon content is sufficiently high these particular gases are solidified, and blowholes from this cause less frequent. When the silicon content is too low the soluble gases are dissolved and blowholes may be anticipated. The outer surface of the metal is usually chilled before these blowholes are formed, and they are not ordinarily discovered until after machining or the skin is otherwise disturbed. These blowholes are usually very small but sometimes either multiply or swell up to such an extent that even shrinkage cavities or pipes are filled up. As the silicon content is very much lower in steel than in iron this accounts, in a large measure, for the greater prevalence of blowholes in steel than in iron.

Surface defects are usually found on the upper surfaces of the castings. They are caused by loose sand floating to the top and becoming embedded in the surface of the metal. This loose sand may have been washed off by the running metal as the result of imperfect drying, spalling off of patches, insufficient nailing of the cope and the bottom of sprues on other parts where erosion is excessive. Sand or dirt not thoroughly blown out before closing up the mould will produce the same evil effect. Sand of low refractoriness will soften and burn into the casting. The effect of this will not be limited to the upper surfaces, but show over the whole casting. Warping is generally the result of internal stresses set up by uneven cooling or from sagging on account of not being properly supported in the annealing furnace. Cold shuts result from cold pouring. If the metal running around cores or from different gates is too cold when the streams meet, they will not make a perfect union. This fault is termed a cold shut.

Welding.—Steel castings of the kind under consideration are rarely rejected now on account of shrinkage cracks or cavities and blowholes where satisfactory repairs can be made by welding. When electric arc, oxy-acetylene or thermit welding were in their infancy, prejudice against them was so general that many of the castings now salved would have gone to the scrap pile. The art of welding has become so well understood that it occupies a recognised place in the steel foundry and for making repairs on vessels in commission. A skilled arc or torch operator should have no difficulty in making a perfect weld. If any poor metal is run in, he knows it and should cut it out. He should not proceed to cover it up. Large cracks or breaks should preferably be repaired by thermit welding. Whichever process of welding is adopted, all bad material and sufficient steel in way of cracks should be cut out so that the parts can be thoroughly preheated and space provided for running in the metal.

Welding metal is run in so hot that a hard crystalline structure extending into the casting results. It is therefore advisable to do all possible welding before annealing. Castings on which important welding has been performed after annealing, or that require machining in way of the same, should be properly annealed again after welding where possible. Important repairs are often made on broken stern frames in dry dock by the thermit process. These, of course, cannot be properly re-annealed after welding, and yet very few failures have been recorded. This is accounted for, in a measure, by the enlarged section of metal provided in the weld after the job is completed.

The operation on the stern frame of the U.S. SS. Saratoga presents one of the most interesting and important examples of salvage work on record. The writer is indebted to the New York Shipbuilding Corporation, builders of the Saratoga, for photographs, illustrating this

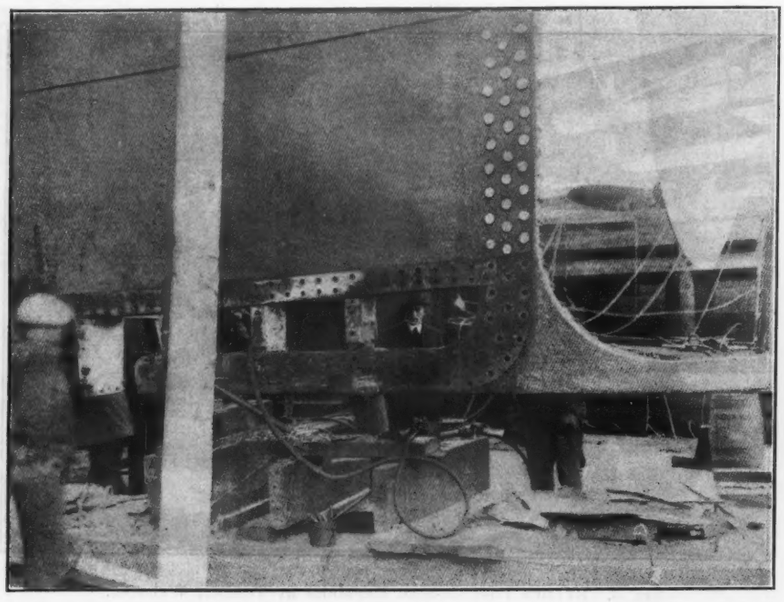


Fig. 8. Repaired Stern Frame; SS. "Cape May."

Fig. 9. SS. "J. F. Hylan;" Repaired Shoe

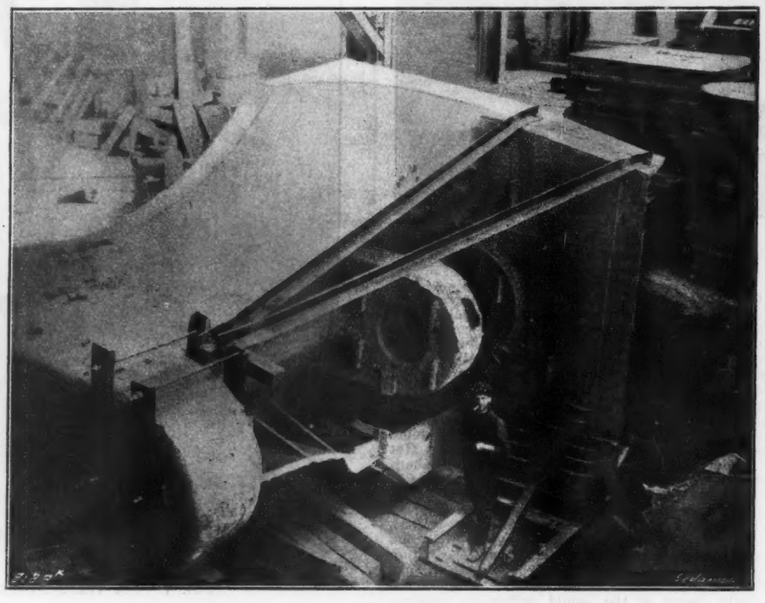


Fig. 10. U.S. SS. "Saratoga"; Rudder-Post Casting Undergoing Repairs.

extraordinary piece of work. We are further indebted to Mr. E. H. Rigg and Mr. W. R. Bean, who personally followed the work, for a description of it, which, we believe, is of sufficient interest to quote in full :—

"Through an unavoidable delay between pouring of the casting and the annealing of the stern frame for the Saratoga, a crack developed during annealing across the large horizontal top of the casting that carries the weight of the rudder. This crack was about 9 ft. long and extended almost from side to side of the casting and completely through the 3 in. of metal forming this flat.

"As this casting was very complicated and expensive, the Navy Department after consultation with the Penn

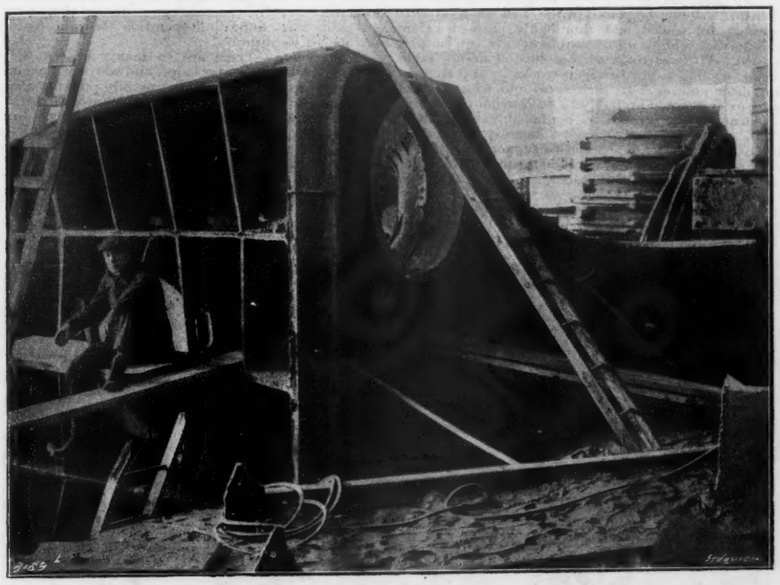


FIG. 11. SS. SARATOGA; RUDDER POST CASTING UNDERGOING REPAIRS.

FIG. 12. DRAG OF STERN FRAME CASTING MOULD.

Seaboard Steel Corporation and the American Thermit Company decided to try a thermit weld for its repair. It was considered necessary completely to separate the two parts of the casting, on either side of the crack, in order that expansion and contraction while preheating and welding would not extend the crack in an undetermined direction. This separation was done by a cutting flame, and at the same time the crack was made about 1 in. wide by burning out the surplus material. This widening was necessary to provide for a free flow of thermit through and around the crack. Due care was of course taken to support the two sections in order to maintain their correct relation to each other.

"The appearance of part of the crack after it had been enlarged and extended by the flame is shown in Fig. 4. The original crack extended from about where the horizontal toe of the angle brace crosses the crack to a corresponding point on the other side of the casting. The casting is shown resting on its starboard side in the annealing pit with the lower side of the flat in view. The pattern for the weld was made by filling the crack with wax and covering the upper and lower surfaces of the flat with the same material for about 2½ in. each side of the crack and for a depth of ¾ in. The box for the mould was next erected and a fine sand rammed in. The necessary vents, risers and gates were provided for, as well as five preheating holes on each side of the box. The casting was preheated by 10 kerosene torches through these openings in the vicinity of the crack for about 14 hours. This heating burnt out the wax and left an empty space along the crack of the desired shape of the weld.

"When the proper temperature had been reached the preheating holes were plugged and the thermit crucible placed over the opening at the top of the mould. This crucible, which contained about 1,500 lb. of thermit, did not rest on the mould but was suspended from a crane. The thermit was then ignited, and as soon as the reaction in the crucible became general the plug in the bottom of the crucible was opened and the metal allowed to run into the mould. Fig. 5 gives a general view of the casting and shows the weld on the under side.

The repaired stern frame was cast by the Penn Seaboard Steel Corporation, Chester, Pa. It was poured February 10, 1922, but not annealed until some time in October of the same year. During this interval of approximately eight months it was left in the mould pending decision, on account of the Arms Limitation Conference, as to whether the Saratoga would be scrapped or converted into an airplane carrier. The manufacturers contended that the crack, although not observed until after annealing, really occurred before annealing, and that it was the result of internal stresses extending over an unprecedentedly long period and for reasons beyond their control. It is understood the Navy Department accepted the responsibility and paid for the expense incurred on this account.

In the operation of annealing the casting was heated slowly to 1,650 deg. Fahr. and then cooled down slowly to about 1,050 deg. Fahr., after which it was re-heated to about 1,450 deg. Fahr., when it was allowed to cool down slowly to air temperature. The casting was annealed again after the repairs were pronounced satisfactory. An account of this as a concrete example of annealing will be given, following the paragraphs on this branch of the subject. Thermit welding repairs on stern frames and other castings for ships done in place are no longer a novelty. Some of these are illustrated in Figs. 6 to 9.

Moulding of Stern Frame for U.S. SS. Lexington.— During the writer's visit to the Penn Seaboard Steel Corporation, for the purpose of observing the moulding operations on the stern frame of the U.S. SS. Lexington, a sister vessel of the U.S. SS. Saratoga, Mr. W. S. Haney offered to take a number of photographs showing the various stages of work about the time the mould was ready for fitting up. With a design as complicated as the one in this case, a study of Figs. 4, 5, 10 and 11 inclusive will assist in a better understanding of the photographs taken of the moulding operations. Fig. 12 shows the drag of the mould after drying ready for the drawbacks to be set in position. Fig. 13 shows one of the drawbacks as it comes from the oven. Fig. 14 shows the mould with all the drawbacks in position ready for the placing of the cope. It is hardly necessary to say that the manufacture of castings of this description requires the most careful supervision and greatest possible skill on the part of the mechanics. Each step in the many operations must be anticipated and most carefully planned out in advance of commencing the work.

FIG. 13. DRAWBACK FOR STERN FRAME CASTING.

FIG. 14. STERN FRAME MOULD READY FOR COPE.

The mould was constructed in a pit 18 ft. by 14 ft. by 10 ft. deep. This provided the necessary space for getting around the pattern and for the construction and removal of the drawbacks. The first operation consisted of placing four binders in the bottom of the pit in conjunction with bottom plates carried across between them. Heavy hook rods were extended up from each binder to be readily available for holding down the cope when this part of the mould was finally placed in position. About 20 in. of sand was then rammed over the binders and bottom plates. The next operation was to place the pattern in position and block it up absolutely true in all directions. Facing sand was then rammed under the pattern so that there was a perfectly solid face on the mould. After this the running of the sand on the sides of the pattern was proceeded with. It will be noted from the illustrations of the casting that the pattern is so constructed that the cores are made by the moulder in place. The cores, or, more properly speaking, drawbacks

were formed during the process of ramming up the sides. On account of the depth of the pattern it was necessary to make the drawbacks in a number of sections to reduce the risk of handling and facilitate lifting of them out for dressing and drying.

The details of constructing drawbacks have been described elsewhere. Attention is called to the nailing of the mould and drawbacks in all of the figures and to the scoring out of the drawbacks in Figs. 13 and 14 to form thin chill brackets for strengthening the corners. After the construction of the mould had been completed up to the parting or joint of the flask, the cope was placed in position and thoroughly rammed. The cope was then removed, nailed, finished and dressed. The drawbacks were then taken out, nailed, dressed and washed. The drag was then nailed and dressed. The cope and drawbacks were dried in the oven. Oil burners at each end of the pit were used for drying the drag. The fitting up of a mould of this character requires careful work and is practically a retracing of the steps in taking down for drying.

It will be noted that, in the design for these castings, uniform distribution of metal has been followed to the greatest possible extent and that, with the exception of very limited enclosed cores, venting can take place freely through the outside sand and drawbacks. For these reasons it was not considered that any other venting of the mould beyond that provided by the risers and the porosity of the sand was necessary. Neither was it considered necessary on a design of this kind to use foreign material to make the mould more collapsible, with the exception of a little hay rope in the vertical walls of the drawbacks.

Shaking-out and Cleaning.—The judgment and experience of the manufacturer must be relied upon in deciding the procedure to be followed in shaking out a large casting. The design, proportions, uniformity of metal, size and weight all have to be carefully considered in determining how long a casting should remain in the sand after pouring, and how much of the mould should be loosened up or to what extent the cores should be removed before the final digging out is commenced. This depends on how soon or to what extent it would be safe to subject the individual casting to air cooling and on the practice of the foundry in the construction of the mould and cores in respect to automatic yielding or collapsibility. Too early exposure to the air, in many cases, would aggravate the internal stresses with the probability that either serious cracks or innumerable infinitesimal cracks too small to be distinguishable might be developed.

Cleaning and cutting off of runners, gates, risers, fins and brackets, &c., should be completed and the casting made ready for the annealing pit or furnace as quickly as possible. Pneumatic tools and a sand blast, for removing sand, are the expedients most commonly used. Fins and brackets may be removed by burning or with a pneumatic tool. Gates and risers are removed by sawing, burning, or drilling according to accessibility. Heat or individual numbers or both should be stamped on castings and coupons for identification before the latter are cut off. After annealing, the coupons are cut off and test pieces accurately machined. Testing may then be proceeded with according to the specifications under which the casting is manufactured.

Annealing.—All cast steel has a coarse crystalline structure and is subject to internal stresses before annealing. The object of annealing is to improve the texture of the steel by breaking up this coarse crystalline structure, to relieve the internal stresses and also soften it for machining. During the heating and cooling of steel, a change in the internal structure occurs at critical points or certain temperatures which vary slightly with the carbon content. Steel castings carry their carbon content in the form of sorbitic pearlite. When heated to a certain temperature the pearlite changes to austenite. If allowed to cool slowly, the austenite is changed back to laminated pearlite. The temperatures at which these changes occur during heating or cooling are designated as critical points frequently referred to, respectively, as decalescence and recalescence.

The work expended or absorbed by these changes in internal structure during the evolutions that occur in the structural arrangement retards both the rising and falling temperatures at the critical points as the casting is being heated or cooled. On being heated up past decalescence there is, at decalescence, an increased absorption of heat which prevents the steel rising in temperature just then as fast as immediately before and immediately after. On being cooled at recalescence there is an evolution of heat causing some steels to grow hotter and causing all steels to cool more slowly while passing through this recalescence point. The temperatures at decalescence and recalescence, or the points where they remain nearly stationary, are not equal. Decalescence is always higher than recalescence. This gap in temperatures between the critical points is accounted for by lag or the time absorbed in overcoming the molecular inertia during the evolutions in the chemical composition. There would be less lag, and the transformations from pearlite to austenite and the reverse would be more complete if the heating and cooling were done more slowly.

It is impossible to give accurate values for the temperatures of the critical range, without determination, for any particular steel. For present purposes the extreme temperatures might be approximately stated as 680 deg. C. to 830 deg. C. In low carbon steels such as steel castings for ships, the phenomena called decalescence and recalescence are most marked at the temperatures at the lower end of the critical range and occur at about 720 deg. C. and 680 deg. C., respectively. Molecular changes referred to above must occur at both critical points, as recalescence cannot be obtained until after decalescence. Annealing therefore cannot be accomplished unless the temperature is raised above both these critical points. Where a steel casting is heated above decalescence the grains assume a definite size for each increase in temperature. The coarseness of the grain increases with the temperature. After being cooled slowly from any temperature above the lower critical point the coarseness of the grain corresponds to that at the temperature from which it has been cooled. It is therefore important, in order to secure the finest possible texture, not to anneal at a temperature unnecessarily above decalescence.

Rapid cooling or quenching in various mediums such as oil, hot or cold water, or air, &c., prior to final annealing would improve the texture but is not applicable in the case of castings, of large or complicated design because the risk of warping and cracking would be too great. No hard and fast rules can be followed in deciding when castings should be placed in the annealing furnace. If castings are cooled and thoroughly cleaned before annealing, the welding up of visible defects can be first completed. With castings of complicated design rapid or uneven cooling might result in cracks at any stage of cooling after pouring. In such cases and where proper facilities exist it would probably be safer to get the casting into the annealing furnace as hot as it can be safely handled. As a safeguard against sagging or warping in the furnace, the casting should be supported on blocks of small area, spaced widely to allow free heat circulation under the casting, but close enough to avoid too large spans between supports.

The temperature of the furnace is slowly raised to from 850 deg. C. to 900 deg. C. and maintained at this temperature for a few hours according to thickness after the casting is uniformly heated through. The cooling should be done even more slowly in the furnace until a black heat is reached, after which it may be cooled in quiet air. The temperature should be kept uniform through the casting until the danger of cracks from internal stresses has passed. If the furnace is too small with respect to the casting, and the flame, in consequence, comes in direct contact with parts of it, the temperature may not be uniform throughout the casting and the annealed structure would be correspondingly less uniform.

While describing the thermit welding repairs to the U.S. SS. Saratoga's stern frame, reference was made to the subsequent annealing, an account of which, it was stated, would follow the above paragraphs. In view of the double heat treatment before welding briefly referred to above, the engineers of the Penn Seaboard Steel Corporation concluded that the procedure for proper annealing after the thermit welding should be as follows: A temporary brick furnace approximately 20 ft. square by 16 ft. high was especially constructed to accommodate this casting. Ample space at all points was afforded to permit of proper heating conditions. Oil burners—six in all—were installed at the four corners of the furnace and in such a way as not to allow the flames to impinge on the casting. Four thermo-couples connected to a Leeds and Northrup self-recording pyrometer were used to indicate the casting temperature throughout the heat. Each couple end was placed in a couple-block, and these couple-blocks were located on the casting top and bottom at both ends. These blocks were of such size as to be equivalent in section to that of the casting at the point of location, thus affording, as nearly as possible, casting temperature at all times.

In order to guard against any possibility of setting up heating strains in the casting during the "Black heat" 36 hours was allowed to raise the temperature from normal up to colour—about 1,050 deg. Fahr. Ten hours were then allowed to raise the temperature from 1,050 deg. Fahr. to 1,570 deg. Fahr., making a total of 46 hours to bring the casting to maximum temperature. Periodical observations made with flames shut off during colour period showed the excellent effects resulting from the slow heating; colour at all times was absolutely uniform and very "mellow" during the holding period. At the end of the stipulated four-hour holding period the temperature was allowed to drop back to 900 deg. Fahr. at the rate of 35 deg. per hour. This was accomplished by "firing back." From this stage on the cooling was allowed to continue naturally. Total firing time, 69½ hours. Inspection of this casting after cooling failed to show any indications of unsatisfactory results; no "pulls" at the line of weld nor warping of any description could be observed. It is the consensus of opinion of those who had charge of this annealing operation that the casting is now in A-1 condition.

Straightening.—There are so many different designs of large steel castings for ships, and warping is so erratic that each case of straightening usually presents a special problem. Sometimes the design, thickness of metal and extent of warping admit of cold straightening. In most cases this can be done better and with greater safety under an hydraulic press. In many cases local heating has been resorted to in straightening and taking out twists in castings of simpler design. The temperature of the local heating should not be greater than necessary to accomplish the purpose and should preferably be kept below the annealing point. The work should be done on a large surface plate. The casting should be firmly clamped to blocks, arranged to fit the straight part. The blocks under the bent part should be set at the proper height for the casting when brought into proper alignment. The usual procedure is to build a local furnace at the point to be heated and draw the casting down by means of turnbuckles or screws until it rests on all the blocks. This controls the amount of straightening. The cooling should preferably take place in the furnace before the clamps and screws are released.

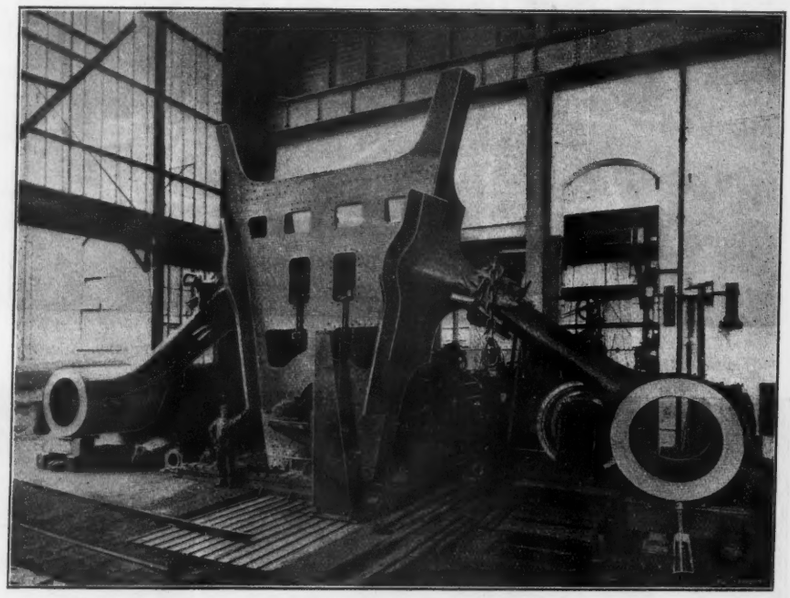


FIG. 15. STERN CASTINGS FOR THE TRIPLE-SCREW LINER "OLYMPIC."

Stern frames, rudders and stems of the simpler designs can usually be straightened in this way when proper facilities are available. There is usually sufficient metal left in shaft bosses for boring to take care of some warping. The ship's lines can often be modified or adjusted in the loft to suit slight changes in form of complicated stern frames or shaft brackets. The scope of the paper will not permit dealing with more special cases.

Included in the illustrations is Fig. 15 not specially referred to or credited in the text. This shows the after-shaft brackets and assembly of the steel stern castings for the triple-screw liner Olympic. Fig 2 shows the pattern of one of the shaft brackets for the cancelled U.S. battle cruisers Constellation and Ranger supplied by the Newport News Shipbuilding and Dry Dock Company. These were sister ships to the U.S. SS. Saratoga and Lexington. I wish to express my thanks to Mr. H. T. Morris and Mr. W. R. Shimer, metallurgical engineers of the Bethlehem Steel Company, for looking over the manuscript and offering valuable suggestions.

BRAZILIAN MANGANESE ORE EXPORTS.—Manganese ore exports from Brazil during the first half of the current year totalled 160,265 gross tons, according to *The Iron Age*, New York, compared with 156,253 tons during the corresponding half of last year.